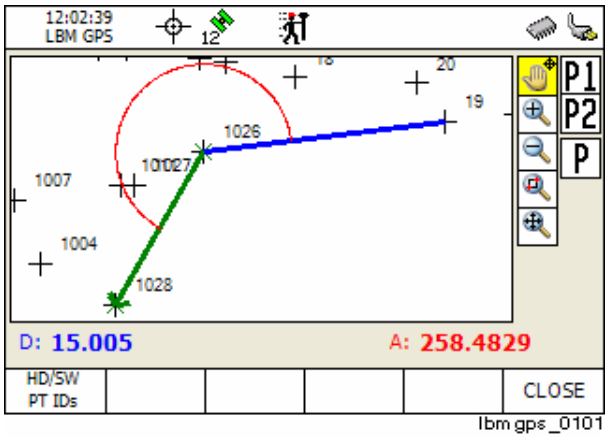
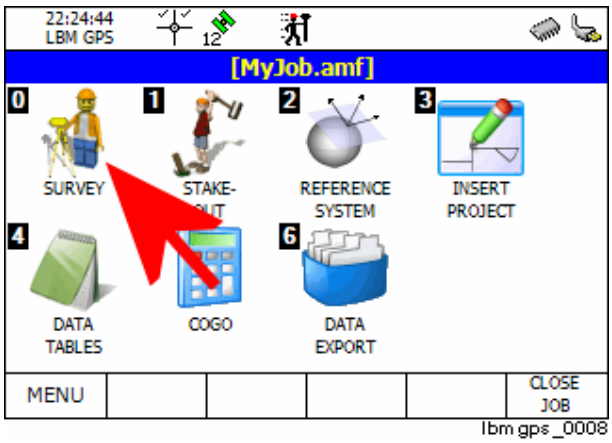
Leica
BuildMobile
GPS/TPS





USER MANUAL

Version 1.5.41.2010

(DocLBMALLMC08/2010)

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Warnings

out, there is a risk of accidents if the operator does not pay the required attention to the surrounding environmental conditions such as but not limited to obstacles, overhead loads, excavation work, heavy vehicles, escarpments.

The person responsible for dockyard security must inform all the operators of the existent dangers.

Trademarks

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1. Introduction to Leica BuildMobile

ree versions: TPS, GPS and XPS

Leica BuildMobile is available in three versions:

- Leica BuildMobile TPS
- Leica BuildMobile GPS
- Leica BuildMobile XPS (available for Italy only).

The three versions are differentiated based on the type of controller/palmtop on which they can be installed and based on the type of instrumentation supported:

1.1 Leica BuildMobile TPS

The TPS version can be installed on Leica DX10 palmtops (or a compatible palmtop with the Microsoft(R) Windows Mobile operating system) and only supports *Total Station* instruments.

1.2 Leica BuildMobile GPS

The GPS version can be installed on Leica RX900 or Leica RX1250 controllers and only supports *GPS* instruments.

To support GPS, the Leica SmartWorx software must be running simultaneously with BuildMobile.

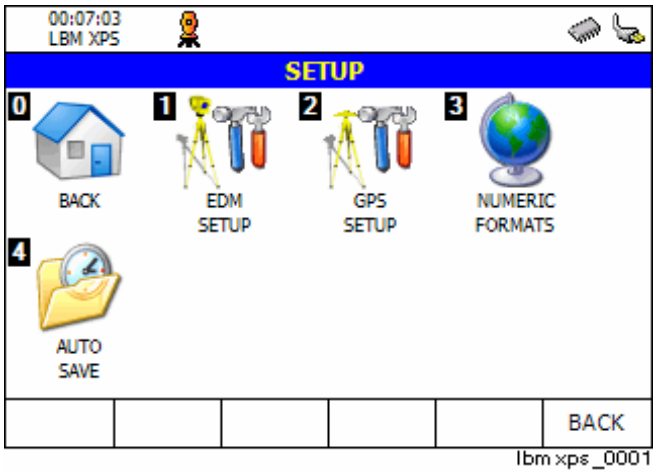
1.3 Leica BuildMobile XPS (available for Italy only)

The XPS version can be installed on Leica RX900 or Leica RX1250 controllers; the characteristics of both the two previous versions, TPS and GPS, are combined into a single product which simultaneously supports *Total Station* and *GPS* instruments.

To support GPS, the Leica SmartWorx software must be running simultaneously with

2. Leica BuildMobile

2.1 Configuration

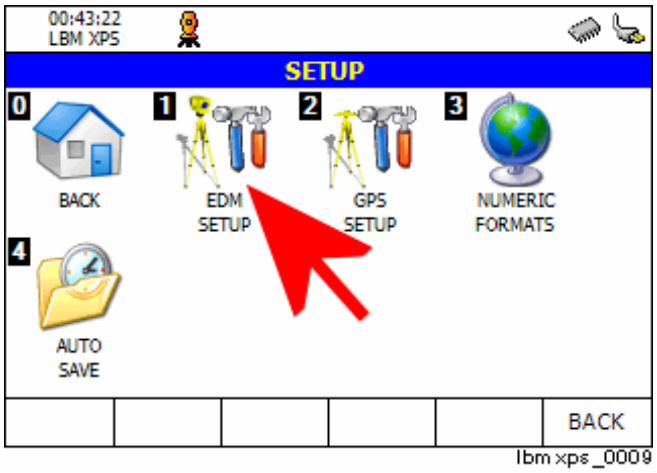


lbm xps_0001

Configuration menu, you can:

- Configure and test the Total Station instrument
- Configure and test the GPS instrument
- Define number formats
- Configure automatic data saving

The configuration menu can be accessed from the main application menu by pressing the *SETUP* button or, if a job is open, by pressing the buttons *MENU* then *SETUP*.



lbm xps_0009

-
-
-

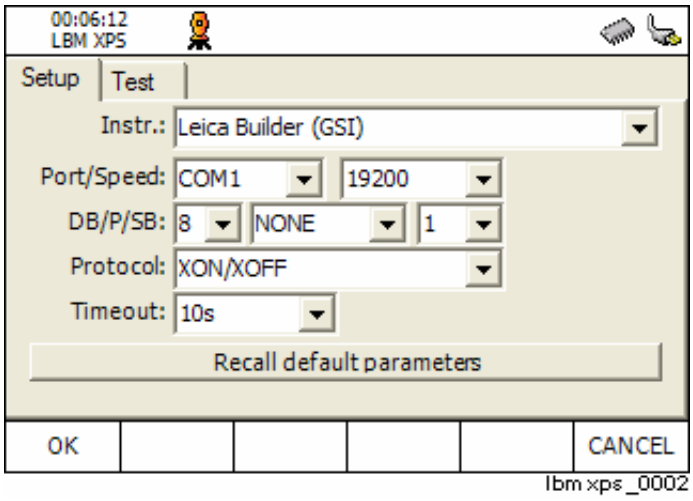
Additionally, the following families of non- Leica instruments are supported:

- Geomax ZTS60x, Zoom20, Zoom30
- Stonex STS02/05
- Wild T/TC1010-1610, Wild TC500, Wild TC600
- Sokkia (One-way): to drive most of the Sokkia instruments
- Sokkia (Two-way): alternative driver to be used only in case the previous driver does not work
- Pentax PTS-III, PTS-V, PCS, R300 series
- Geotronics 400 mono-directional
- Geotronics 400/500/600 series
- Trimble 5000, 5000 servo series
- Topcon GTS ("Topgun"), ET-1/2
- Nikon DTM 5-20, DTM 720/730/750, DTM A10/20
- Nikon 300 series
- Spectra Focus 10, Focus 10 servo.

If you wish to insert the measurements by hand, that is by entering the measurement values through the palmtop keypad, the driver called *Manual Input* can be enabled. While using this driver, each time a measurement is taken, a dialogue window will be shown for inserting the measurement data (vertical angle, horizontal angle, slope distance and the height of the reflector, if any).
The communication parameters must be indicated for all the drivers, with the sole exception of the manual insertion driver. See Configuration of the serial port (TPS).

Once the configuration of the serial port is defined, a communication test with the instrument can be carried out. See Instrument test (TPS).

2.1.2. Configuration of the serial port (TPS)



The communication between the palmtop and the instrument occurs through an RS232 serial port (with wire) or through a virtual serial port (Bluetooth). In both cases, the application must be configured so that it uses the same communication parameters set on the Total Station instrument.

Generally, COM1 is the wired serial port while the virtual serial port (Bluetooth) is either COM6 or COM7. COM4 can be associated with a GPS device.

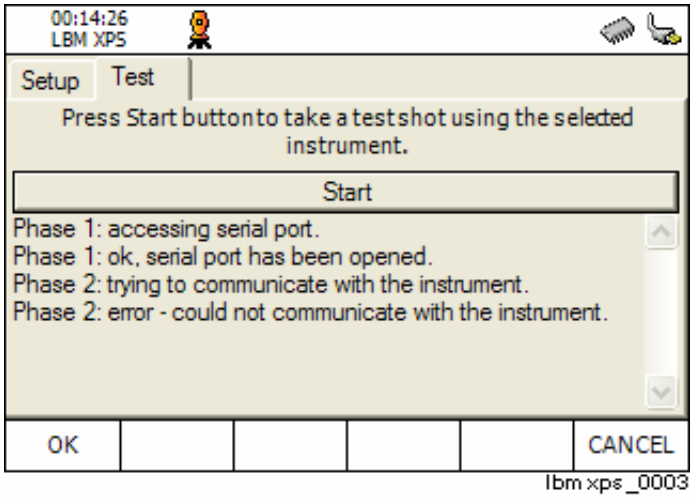
The COM8 port in the Leica RX900 and RX1250 controllers is used to communicate with the Leica SmartWorx (GPS) software.

The parameter called *Timeout* indicates how long the application must wait until the instrument takes the measurement and sends the data to the palmtop through the serial port. It is the maximum time after which the application signals a timeout or time expired error. In case the application always gives a timeout error, it is possible that the maximum time set is very low (normally 10 sec. is enough), or the communication parameters are wrong, or the wire is defective, or the instrument is not enabled for serial communication or is busy with some other operation.

See also: Instrument test (TPS).

2.1.3. Instrument test (TPS)

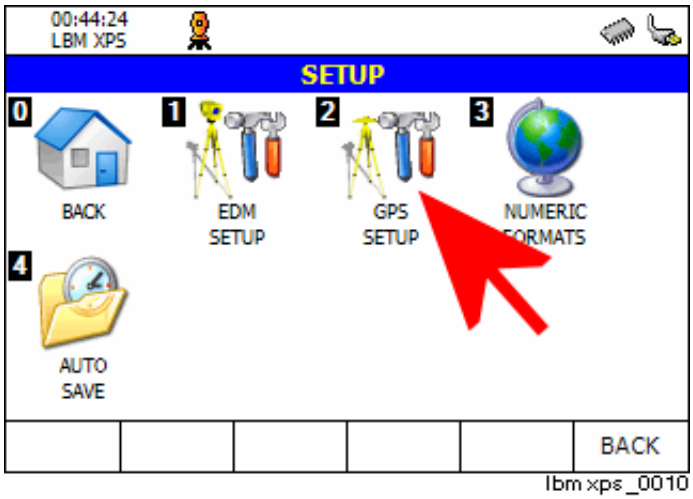
Before proceeding to test the instrument, it is best to verify that the serial communication parameters are correct. It is not possible to execute the test if the *Manual Input* driver is enabled.


00:14:26
LBM XPS
Setup
Test
Press Start button to take a test shot using the selected instrument.
Start
Phase 1: accessing serial port.
Phase 1: ok, serial port has been opened.
Phase 2: trying to communicate with the instrument.
Phase 2: error - could not communicate with the instrument.
OK
CANCEL
lbm xps_0003

Before starting the test, configure the Total Station instrument and enable it to take a measurement (for non-prismless instruments it will be necessary to "aim" at the prism) and then press the *Start* button.

Messages indicating the test progress will be shown in the space under the *Start* button. If the test is successful, the measurement data will be shown; in case the test is not successful, one or more error messages will be shown.

2.1.4. Configure and test the GPS instrument

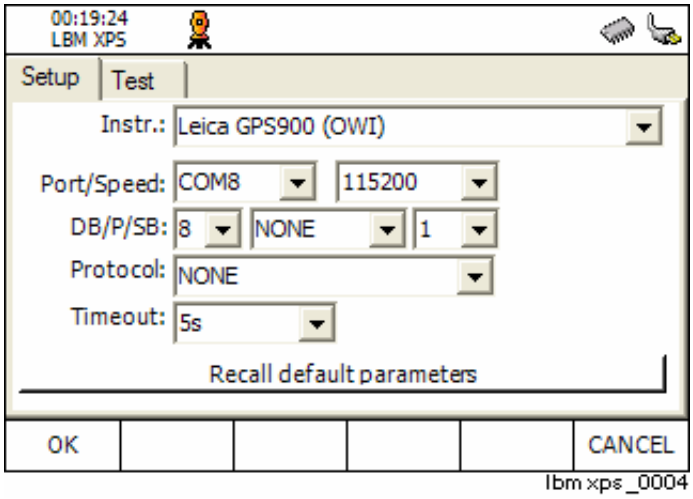


The application has been designed to manage and support only the Leica GPS900 instruments. On these devices, it is mandatory to run the Leica SmartWorx software before Leica BuildMobile.

Leica BuildMobile and the GPS communicate through a virtual serial port created by the SmartWorx software. In order for the communication to take place, the communication parameters must be indicated: See Configuration of the serial port (GPS).

Once the configuration of the serial port is defined, a communication test with the instrument can be carried out. See Instrument test (GPS).

2.1.5. Configuration of the serial port (GPS)



Leica BuildMobile and the GPS communicate through a virtual serial port created by the Leica SmartWorx software and this software must be running simultaneously with BuildMobile.

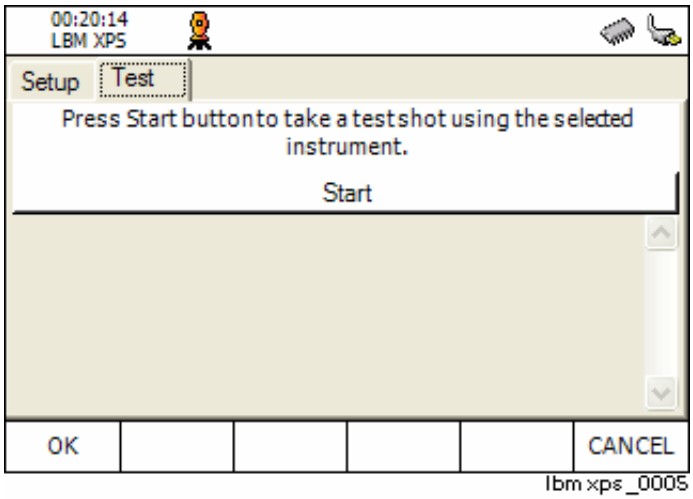
The application must be configured so that it uses the correct communication parameters; these parameters are:

- Port : COM8
- Speed : 115200
- Data bits : 8
- Parity : None
- Stop bits : 1

- Protocol : None
- Timeout : 5 seconds

See also: Instrument test (GPS).

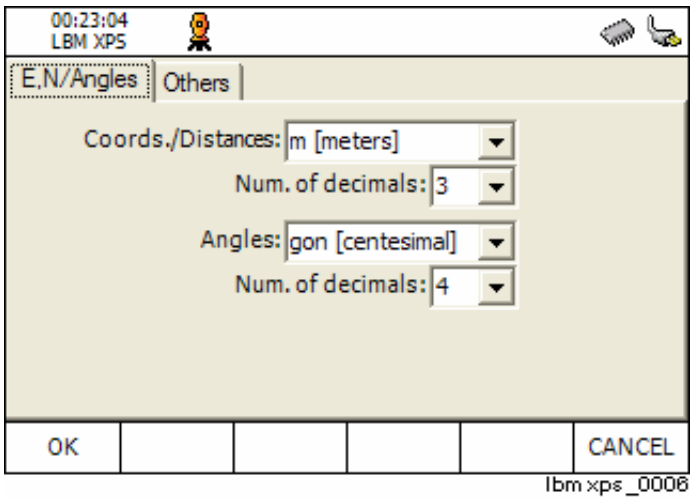
2.1.6. Instrument test (GPS)



Before proceeding to test the instrument, it is best to verify that the serial communication parameters are correct.

Before starting the test configure the GPS instrument, turn on the antennae, verify that the Leica SmartWorx software is running and that it has detected the antennae, then press the *Start* button. Messages indicating the test progress will be shown in the space under the *Start* button. If the test is successful, the current GPS position will be shown; in case the test is not successful, one or more error messages will be shown.

2.1.7. Define number formats



Number formats inform the program of the units of measurement that must be used for the different sizes/quantities, typical to a topographic/cadastral problem. The unit of measurement and the decimal places to be used (rounding off for display) can be defined by choosing among the displayed options for the following sizes/quantities: coordinates/distances, angles, areas, volumes.

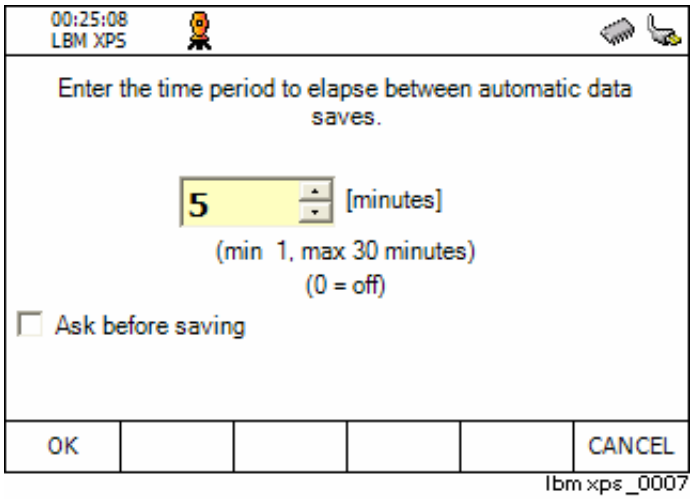
The options are stored and automatically prompted every time the program is run. Thus they are independent of the currently loaded job.

The predefined settings are:

- **Coordinates/distances**: In metres and for 3 decimal places (display rounded off to the millimeter)
- **Angles:** In centesimal degrees and for 4 decimal places (display rounded off to the ten thousandth of a degree)
- **Area/surface area:** In square metres and for 2 decimal places (display rounded off to the square centimeter)
- **Volumes:** In cube metres and for 2 decimal places (display rounded off to the cube centimeter).

In no way do the number of decimal places for display limits the number of decimal places used internally to perform the calculations (IEEE-754 standard which guarantees precision of around 15 decimal places).

2.1.8. Configure automatic data saving

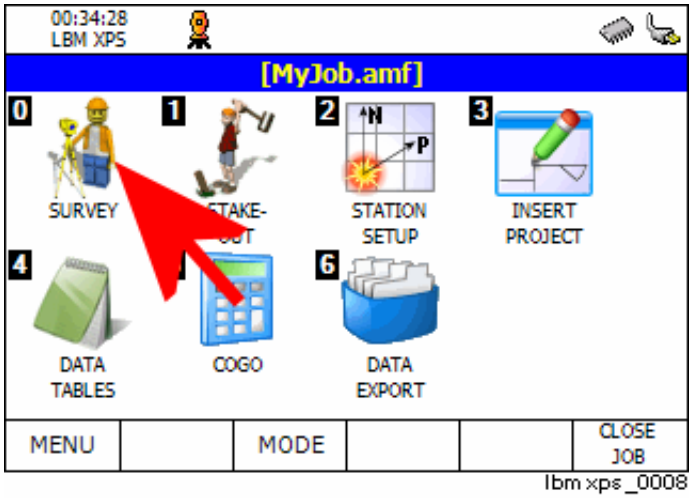


To avoid losing parts of the work (due to various causes such as depleted battery), the program can be configured to automatically save the data (onto a file). The automatic data saving can be programmed to start at regular intervals (from 5 to 60 minutes). To disable automatic saving set the interval to 0 (zero) minutes.

Normally, automatic saving is executed without any user confirmation. However, the program can be made to display a save request by flagging the *Ask before saving* option.

For each save, the program creates backup copies of the original file. These copies have the same name as the original file but the file extension is modified to ~W1, ~W2 and ~W3 (from the most recent to the least recent). In case the original file is damaged, part or all the work can be recovered by renaming the file with these extensions. Since the palmtop operating system hides the file extensions, connect the palmtop to a PC, then access it from *Explorer/Computer* file browser and change the file extension to ".AMF" (without quotes).

Survey



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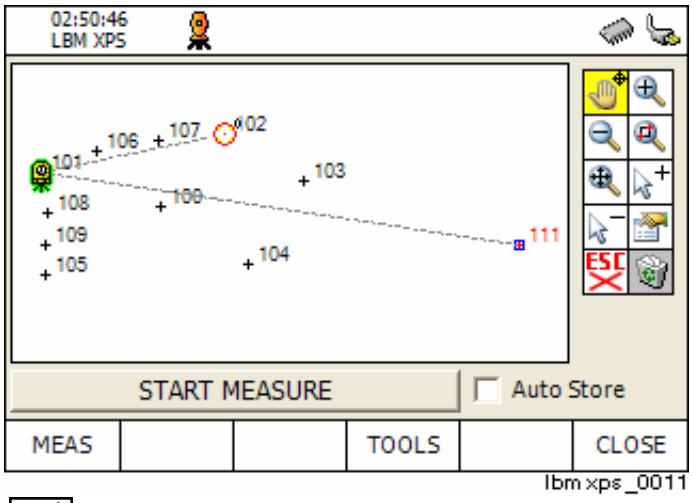

lbm xps_0011

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Point List and the measurement data corresponding to that point is stored in the measurement list of the active station (field book).
See also Data tables.

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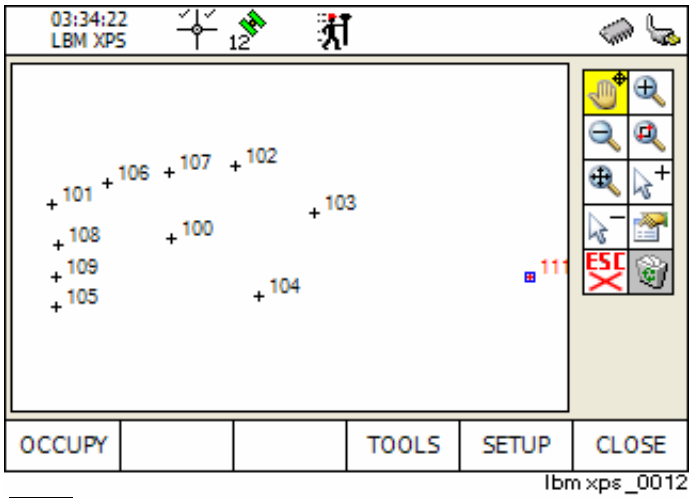
2.2.2. Surveying with GPS

Before starting the survey phase, the reference system to be used must be defined. If you attempt to start the survey phase without having defined the reference system, the application will automatically return to its definition menu. See Definition of the reference system.



lbm xps_0012

Once the survey phase has been started, a view of the map is displayed on a small CAD.

The CAD has instruments (buttons to the right) to a pan/zoom, select/deselect, modify points and delete points.

The following table gives a short description of each tool.

Pan: Tap and drag to move the dimensional plan

Zoom in: Tap to enlarge

Zoom out: Tap to reduce

Zoom window: Tap and drag to define the rectangular area to be enlarged

Zoom to fit: Displays the complete map

Select: Tap on a point to select it

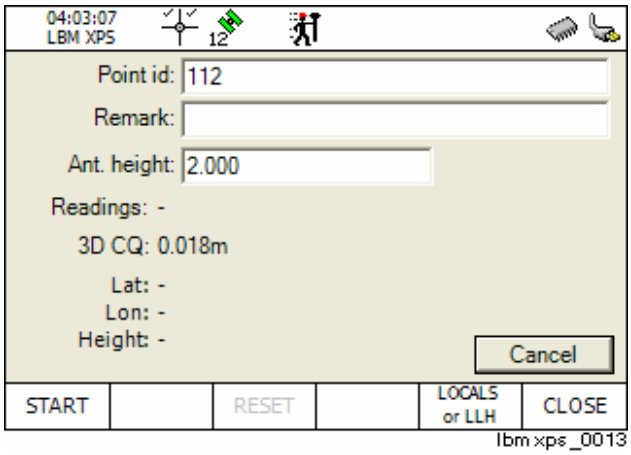
Unselect: Tap on a point to unselect it

Properties: Shows the properties of the selected point

Esc: Cancels the last step of the active instrument/cancels the active selection

Delete: Deletes the selected point

At the bottom of the screen, immediately below the CAD view, the *Occupy* command is shown which, if pressed, acquires a point. The application will show a dialogue window where it is possible to enter the code/number of the point to be acquired, any comment that must be associated with the point and the height of the antenna (phase center). The antenna height is stored and is automatically reintroduced at every point acquired subsequently: hence this value need not be inserted any more. In case the antenna height is modified (physically, not programmatically) it is enough to enter the new value which will become



lbm xps_0013

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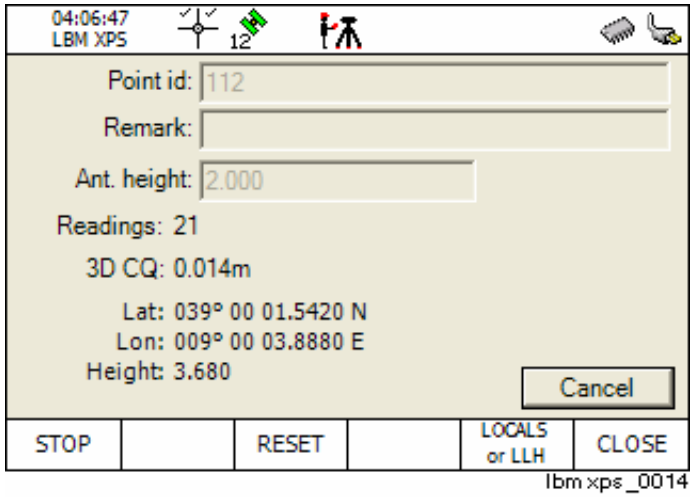
the new default value.

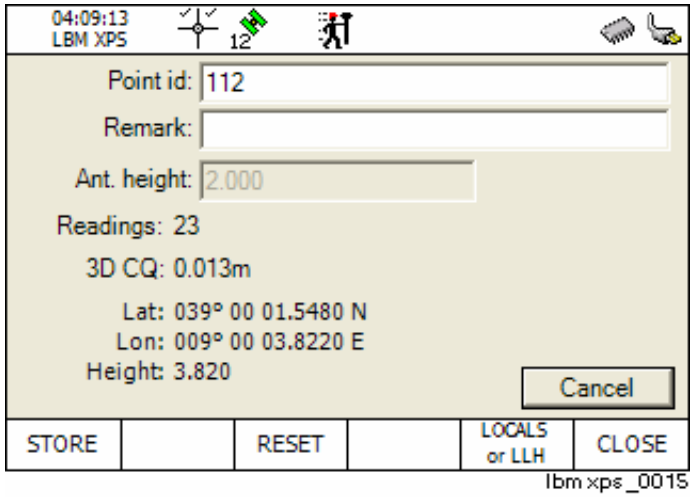
After entering the required values, verify that the GPS pole is perfectly vertical and then start acquiring the points by pressing the *Start* button.



lbm xps_0014

The program will activate the acquisition phase and will show the following continuously on screen: the number of readings taken, the 3D CQ and the current coordinates. It is possible to switch from the geographic coordinates to the ones defined by the active reference system and vice versa

by selecting the *Locals or LLH* command.



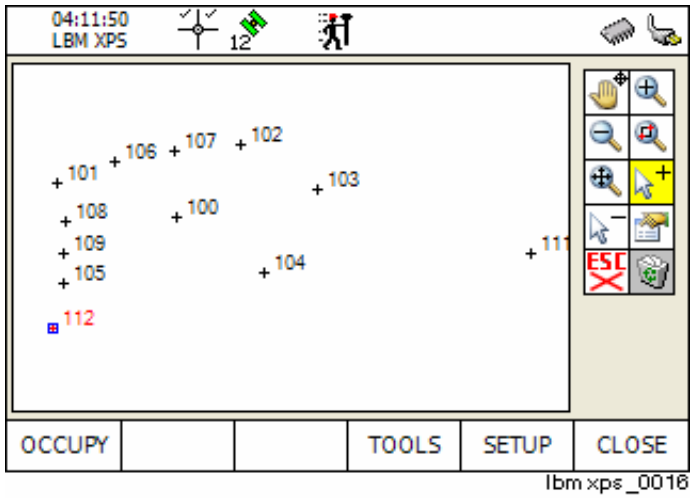
lbm xps_0015

Wait until the 3D CQ value (quality of coordinates, it expresses the estimated error of the current GPS position in meters) is not very high (typically 1-2 centimeters or millimeters) then press the *Stop* command (displayed during the acquisition phase in the place of the *Start* command).

If the GPS can calculate the geographic coordinates (latitude and longitude), the *Store* command will be shown in the place of

Stop.

Press the *Store* button to store the acquired point. The point can be reacquired by pressing the *Reset* button, and then pressing the *Start* button which will be shown in the place of *Store.* Alternatively, if you wish to quit acquiring the point, press the *Close* button.



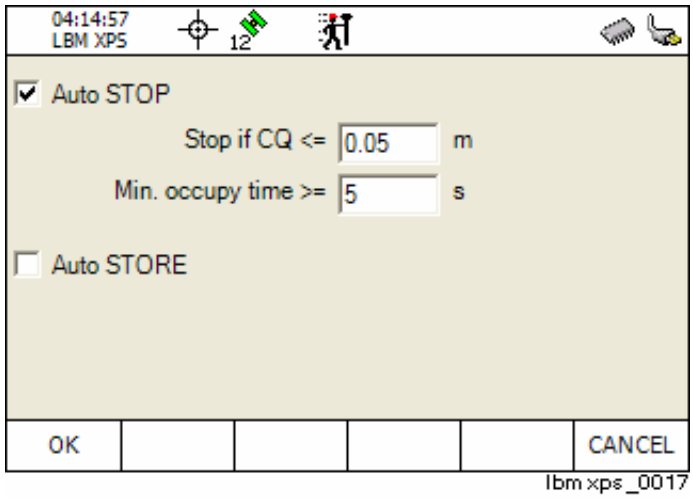
lbm xps_0016

Once the point has been acquired, or on quitting the process, the program will close the acquisition dialogue window and will reopen the main window with the CAD view.

In case the point has been confirmed with *Store,* the program will show this point in the CAD view, moving the frame of the dimensional plan to show the most recently acquired point at the center of the view.

The acquired point will be selected automatically so that it can be immediately deleted or its properties (comment, graphical symbol) modified by using the specific commands (buttons to the right of the graphical view).

Automatic stop of the acquisition and automatic storing of the point can be activated. On pressing the *Setup* button, the program will show a dialogue window to define the necessary parameters:

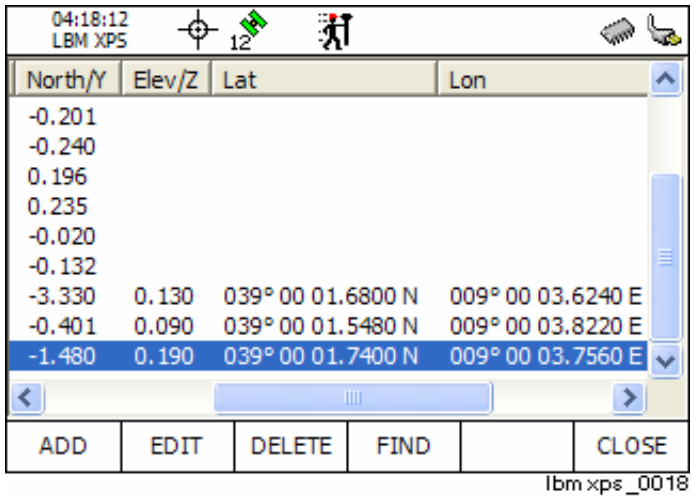


lbm xps_0017

- Auto STOP: if this option is activated, the acquisition of the coordinates will stop automatically once it reaches a CQ which is less than or equal to the indicated one (field *Stop if CQ <=*) but only if the occupation period of the point is greater than the minimum occupation period indicated (field *Min. occupy time >=*).
- Auto STORE: If this option is activated, after acquiring the coordinates, the program automatically saves the point and closes the acquisition window. The automatic saving occurs only if the *Auto STOP* option is also active and the requirements of that option are also satisfied (see the point above).

All the acquired points are saved in the *Point List*. This list can be accessed without ending the survey phase, by pressing the *Tools* button and then pressing *Point List*. It will be possible to modify, add or delete points from the *Point List*.

See also Point List.



lbm xps_0018

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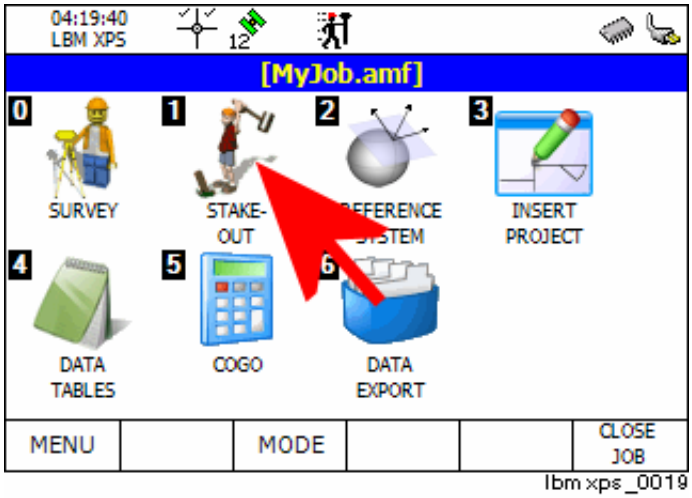
2.3. Stakeout



lbm xps_0019

The application can stakeout points using Total Station or GPS. The preparation phases for the stakeout of points are different based on the instrument used. See:

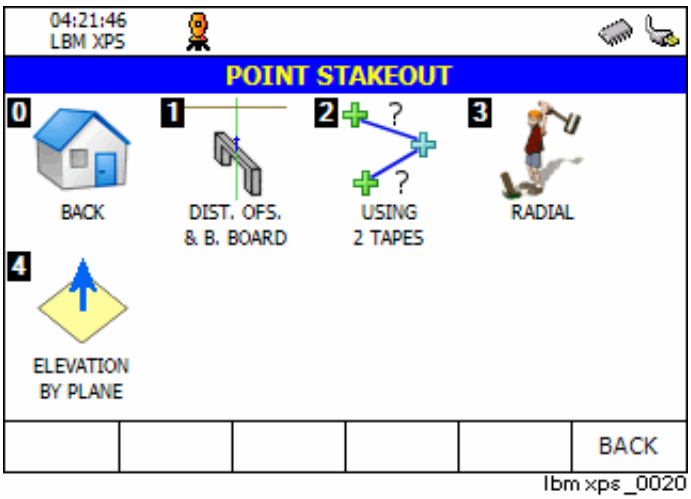
- Stakeout with Total Station
- Stakeout with GPS.

2.3.1. Stakeout with Total Station

Using the stakeout tools through the total station, the position of the points on the ground can be determined in various ways.

See:

- Stakeout by distance and offset and placing of nails on batter boards
- Taping
- Polar stakeout
- Reference plane stakeout



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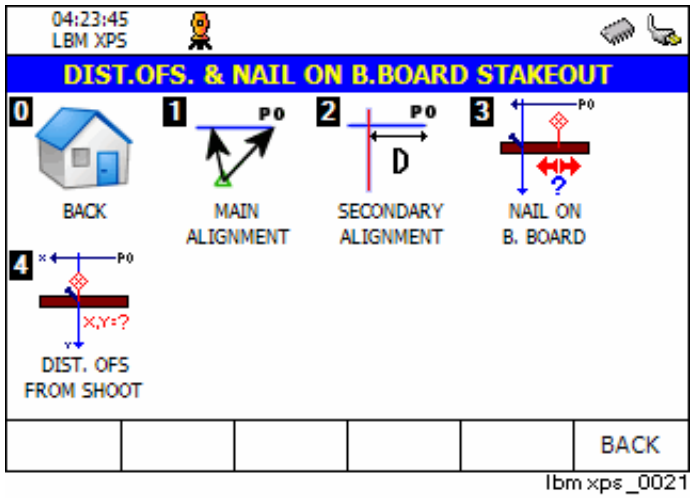
2.3.2. Stakeout using distance and offset and Placing of nails on batter boards (TPS)

Stakeout using *distance* and *offset* and stakeout *to place nails on batter boards* uses a defined line on the ground (principal line) as reference, and a second line which is parallel or perpendicular to the first line only to place the nails on the batter board.

Two points which have already been identified are necessary to define the principal line: the coordinates of these points need not be known since the calculations for the plotting are always relative to the line and completely independent of the other points acquired and existing in the *Point List*.



For further details on stakeout see:

- Stakeout by distance and offset
- Placing of nails on batter boards.

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2.3.3. Plotting using distance and perpendicular (TPS)

Stakeout by *distance* and *offset* consists of calculating the position of the point to be plotted expressed as two distances relative to the reference line: the first distance is along the line (distance X) while the other is perpendicular to the line (distance Y).

The distance along the line is in reference to its point "zero" and this being the first point measured in the definition of the line. This distance will be positive if the point to be staked out is situated beyond the "zero" point and towards the second point on the line. Conversely, the distance will be negative if it is beyond the "zero" point and in the opposite direction of the second point on the line.

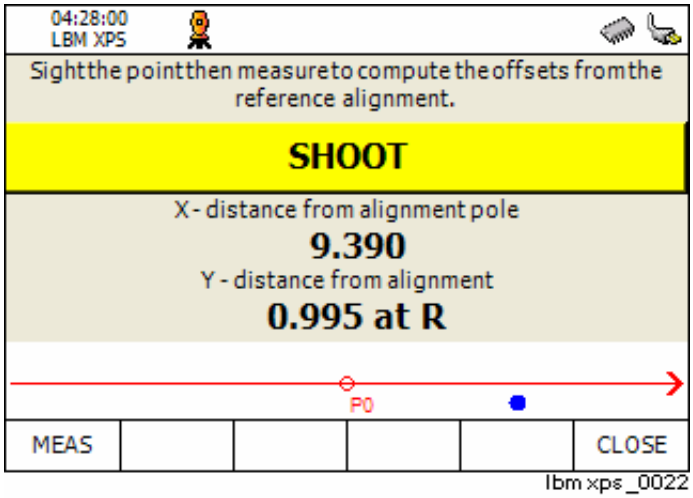
The distance perpendicular (the *offset*) to the line will be negative if the point to be staked is to the right of the line (taken from point "zero" towards the second point), positive if the point to be staked is to the left of the line.

To define the reference line see: Definition of the principal line

To start the *stakeout by distance and offset*, select the following items in sequence from the active job menu: *Stakeout*, *Dist.Ofs. & B.Board*, *Dist. Ofs. From Shoot.*

The stakeout dialogue window features:

- A button to start measurement, on top
- The information of the two perpendicular distances corresponding to the measured point and relative to the reference line, in the center
- A schematic representation of the measured point position with respect to the line, at the bottom



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The schematic representation of the measured point position is ***not scaled*** and must be used solely as a visual reference.

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2.3.4. Placing of nails on batter boards (TPS)

The stakeout *to place nails on the batter board* involves calculating the position of the point on the batter board in which to place a nail after having defined a principal reference line and a secondary line, parallel or perpendicular to the principal line, passing (perpendicularly) through the batter boards.

By measuring the position of the prism placed on the batter board one or more times, the program indicates the distance of the measured point from the point of intersection between the imaginary axis passing through the batter board and the secondary line. This point of intersection is where the nail must be placed.

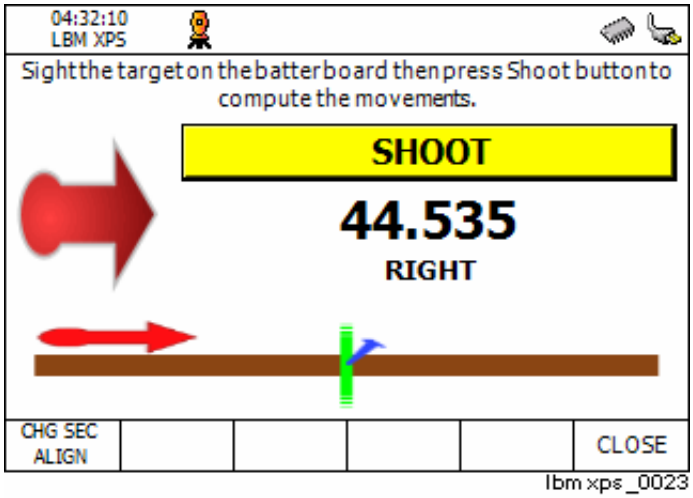
To define the reference lines see:

- Definition of the principal line
- Definition of the secondary line.

To start the staking out of nails on the batter boards, select the following items in sequence from the active job menu: *Stakeout*, *Dist.Ofs & B.Board*, *Nail on B. Board*.

The stakeout dialogue window features:

- A button to start measurement, on top
- A display of the distance of the measured point from the point in which the nail must be placed (distance along the imaginary axis passing through the batter board), in the center.
- A schematic display of the batter board and the position of the measured point with respect to the batter board and the position in which to place the nail, at the bottom



The "LEFT" and "RIGHT" textual messages are ***in reference to the instrument handler's point of view.***

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2.3.5. Definition of the principal line (TPS)

The *principal line* is a line defined between two points on the ground and used for staking using *distance and offset* and for staking *to place nails on batter boards.*

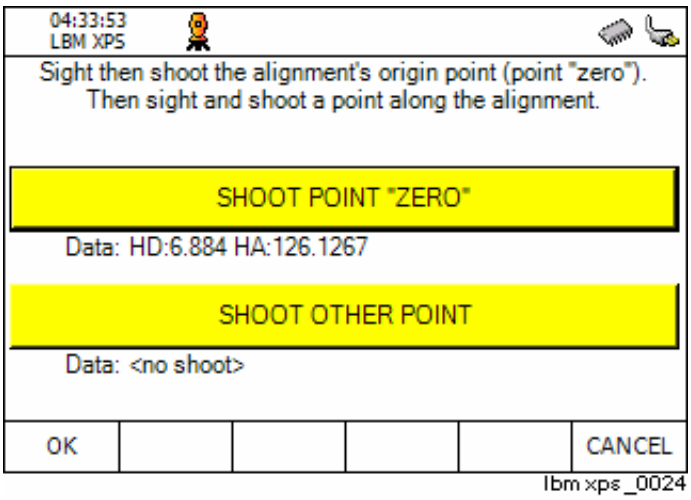
The definition of the principal line involves the measurement of two points defined as point "*zero*" (origin of the line) and *second point.* The second point defines the positive direction of the line (the line is like the axis of abscissas of the Cartesian system of reference).

To start the definition of the principal line, select the following items in sequence from the active job menu: *Stakeout*, *Dist.Ofs. & B.Board*, *Main Alignment.*

The displayed dialogue window consists of two buttons:

- The first button enables the measurement of point "zero";
- The second button enables the measurement of the second point.

Once the two points are measured, the dialogue window is closed automatically, showing the *Dist.Ofs. & Nail on B.Board Stakeout* menu in the first level, to indicate the activation of the alignment for the two points that were just measured.



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2.3.6. Definition of the secondary line (TPS)

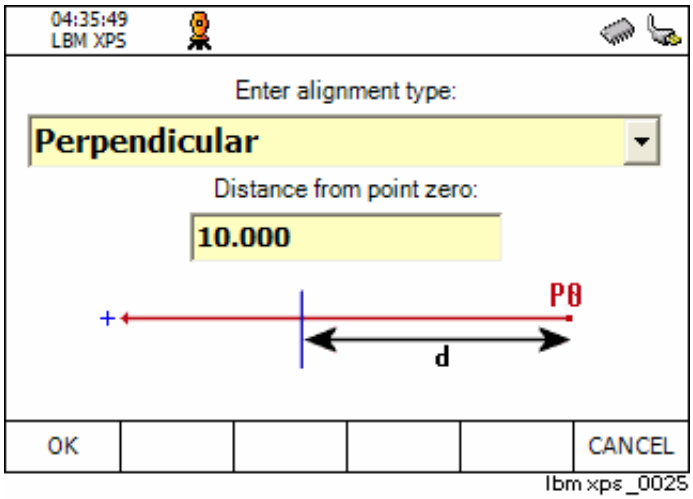
The *secondary line* is a line which is **parallel or perpendicular** to the *principal line* and placed at a given distance from the principal line point "zero" (perpendicular secondary line) or at a given distance from the principal line (parallel secondary line).

Both the lines are used to stake the *position of the nails on the batter boards.*

To start the definition of the secondary line, select the following items in sequence from the active job menu: *Stakeout*, *Dist.Ofs. & B.Board*, *Secondary Alignment*.

The displayed dialogue window consists of:

- A list to select the type (disposition) of the alignment with respect to the principal line, that is to indicate whether the secondary line will be *parallel* or *perpendicular* to the principal line;
- A box to enter the wanted distance.



The significance of the distance varies based on the disposition of the line with respect to the principal line:

Parallel alignment

The value inserted determines the distance between the two lines. The sign indicates the part of the principal line the secondary line must lie in, taking the principal orientation from point "zero" to the second point. A negative value indicates "to the right" and a positive value indicates "to the left".

Perpendicular alignment

The value inserted determines the distance of the intersection point of the two lines from point "zero" (origin of the principal line). The sign indicates which part, with respect to point "zero", along the principal line, the secondary line must pass through: A positive value indicates that the line will cross the principal line at a point "in front of" point zero, or a point which lies in the half line that originates from point "zero" and passes through the second point. A negative value indicates the second line will cross the principal line in a point that is "behind" point "zero".

2.3.7. Taping (stakeout by two tapes)

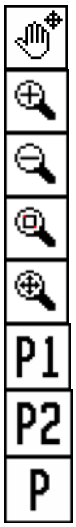
Taping means the identification of a point on the ground given the distances of this point from two other previously identified fixed points on the ground which act as the pins on which the heads of the tapes are anchored.

The application allows the calculation of the (unknown) distances having:

- The planned coordinates of the **point P to be staked out**
- The planned coordinates of **P1** and **P2**, the other two **reference points** which have already been identified on the ground.

To start the taping procedure, select the following items in sequence from the active job menu: *Stakeout*, *Using 2 Tapes*.

Once the taping phase has been started, a view of the dimensional plan is displayed on a small CAD. The CAD has instruments (buttons to the right) to pan/zoom, and indicate the P, P1 and P2 points (already inserted as coordinates in the *Point List*). The table to the side gives a short description of each tool.



Pan: Tap and drag to move map

Zoom in: Tap to enlarge

Zoom out: Tap to reduce

Zoom window: Tap and drag to define the rectangular area to be enlarged

Zoom to fit: displays the complete map

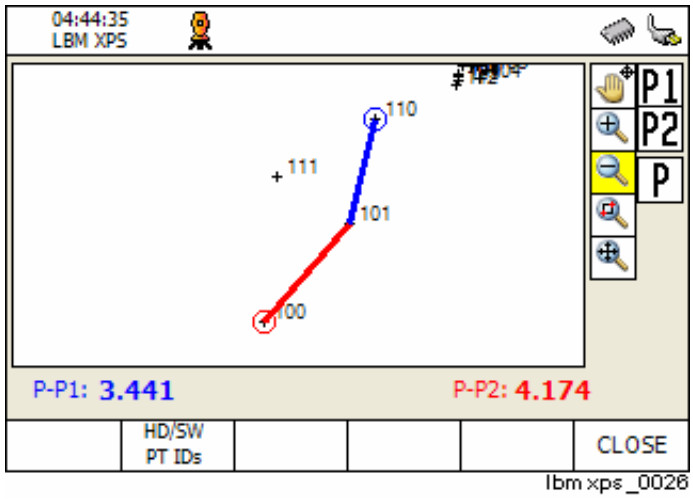
P1: Select the first reference point

P2: Select the second reference point

P: Select the point to be staked out

Use the **P1** and **P2** tools to indicate the two reference points, then use the **P** tool to indicate the point to be staked out. It is possible to define P1, P2 and P in any order.

Once the said three points have been indicated, the application will display the distance of point P from the other two points: distance P-P1 in blue and distance P-P2 in red. In addition, the distances are also shown graphically in CAD view: the blue line indicates the P-P1 distance and the red line indicates the P-P2 distance.



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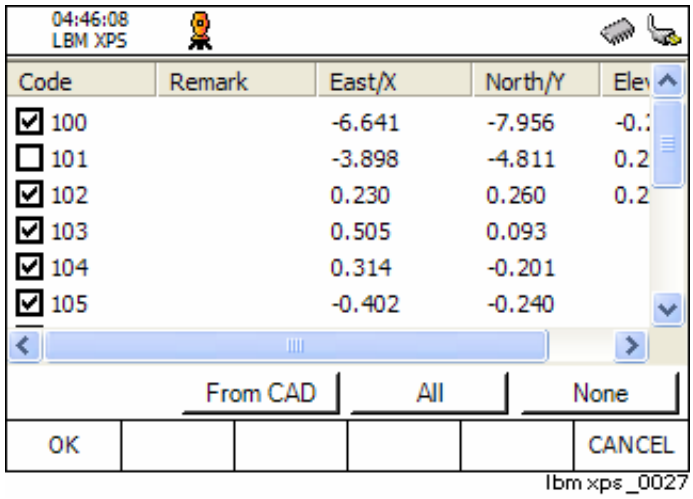
2.3.8. Polar stakeout (TPS)

The *polar stakeout of points* with known coordinates requires the definition of the instrument position, see Station setup.

Once the station has been defined, to access polar stakeout, select the following items in sequence from the active job menu: *Stakeout*, *Radial*.



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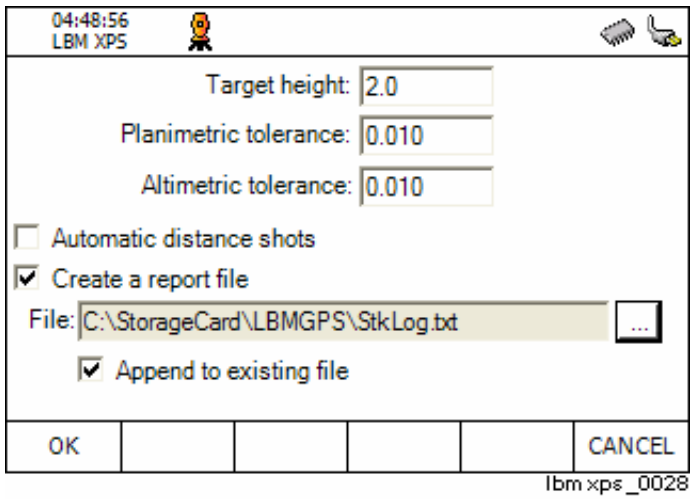
Select the points to be staked out from the list displayed and then confirm.

The next phase consists in specifying the following to the program:

- Reflector height;
- The planimetric tolerance, that is the maximum acceptable distance between the measured point and the planned point;
- The altimetric tolerance, that is the maximum acceptable height difference between the measured point and the planned point;
- If you wish, you can create a report file using the *Create report file* option which will report the planned coordinates, the staked out coordinates and their difference for each stake out point. By flagging the *Append to existing file* option, the stakeout data will be added at the end of the file indicated, otherwise the file will be deleted and recreated.



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For stakeout that is solely planimetric, the height of the reflector is not required, however, the indication of the altimetric tolerance is necessary even if it is ignored in the stakeout phase.

The *Automatic distance shots* option enables the automatic repetition of the measurements. The repetition occurs at regular intervals but not before the operator has pressed the *MEAS* button at least once.

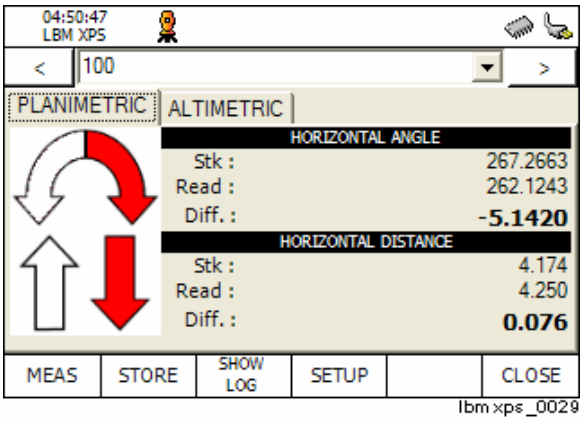
To confirm the data and proceed to the stakeout press *OK,* to cancel the plotting press *Cancel.*

The stakeout dialogue window is divided into three functional parts:

- The list of points to be staked out and the staking commands (on top);
- Information for the planimetric stakeout (page *PLANIMETRIC*);
- Information for the altimetric stakeout (page *ALTIMETRIC*).

Additionally, there are various buttons in the menu at the bottom:

- *MEAS*: Starts a measurement
- *STORE*: Stores the staking data of the active point in the report;
- *LOG*: Displays the staking report;
- *SETUP*: Allows to edit the settings such as prism height, tolerances etc.
- *CLOSE*: Terminates the stakeout phase.



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2.3.9. List of points to be staked out and staking commands

The stakeout of the points can occur in any order. For this purpose, a drop down list allows to select a point to be staked out. The previous or next point can also be selected by using the "<" and ">" buttons.

If a point has been staked out and stored in the staking report, the writing "*[DONE]*" will be shown to the right of the point code/number.

There are three staking commands and they can be activated by using the corresponding buttons:

- Measurement, *MEAS* key, starts the measurement and recalculates the stake out information;
- Storing in the report, *STORE* key, stores the point data (coordinates and difference between the planned and staked out coordinates) in the report.

Information for the planimetric stakeout

The information for planimetric stakeout, referenced from the instrument operator's point of view, provides, via graphical and analytical information, the "instructions" to make the instrument measure the point to be staked out with an error that is equal to or less than the planimetric tolerance set in the options.

The information provided is polar, hence angle and distance.

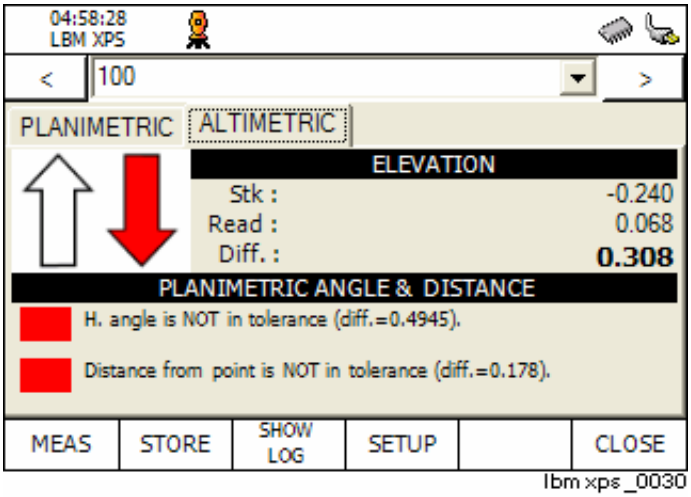
Angle: the application shows the ***staking angle***, the ***measured angle*** and the ***difference between the two*** after each measurement. The staking angle is the angle which must be reached, the measured angle is the one read by the instrument, the difference between the two tends to zero the closer it gets to the correct angle, by turning the instrument, to identify the point on the ground.

To facilitate the reading of data, a graphical representation is present on the left of the analytical values, which indicates to which side to turn the instrument with two arrows. In case the angle on the instrument is correct (within the tolerance indicated in the staking options), the two arrows will be green.

Distance: the application shows the ***staking distance***, the ***measured distance*** and the ***difference between the two*** after each measurement. The staking distance is the distance which must be reached, the measured distance is the one read by the instrument, the difference between the two tends to zero the closer it gets to the correct distance to identify the point on the ground.

To facilitate the reading of data, a graphical representation is present on the left of the analytical values, which indicates whether to move closer to or further away from the instrument with two arrows. In case the distance from the instrument is correct (within the tolerance indicated in the staking options), the two arrows will be green.

Information for the altimetric stakeout



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The information for altimetric stakeout provide, via graphical and analytical information, the "instructions" to make the instrument measure the point to be staked out, with regards to only the height, with an error that is equal to or less than the altimetric tolerance set in the plotting options.

For this purpose, the ***staking height***, the ***measured height*** and the ***difference between the two*** are shown. The staking height is the height which must be reached (planned height), the measured height is the one calculated with the last measurement, the difference between the two tends to zero the closer it gets to the correct height to identify the point on the ground.

To facilitate the reading of data, a graphical representation is present on the left of the analytical values, which indicates whether to "lift" or "lower" the telescope with two arrows so as to reach the correct height. In case the calculated height is correct (within the tolerance indicated in the staking options), the two arrows will be green.

For additional aid, in the lower part of the dialogue window there are reminders of the planimetric stakeout state, in particular:

- Reminder of the state of the horizontal angle (in tolerance or less);
- Reminder of the state of the distance (in tolerance or less).

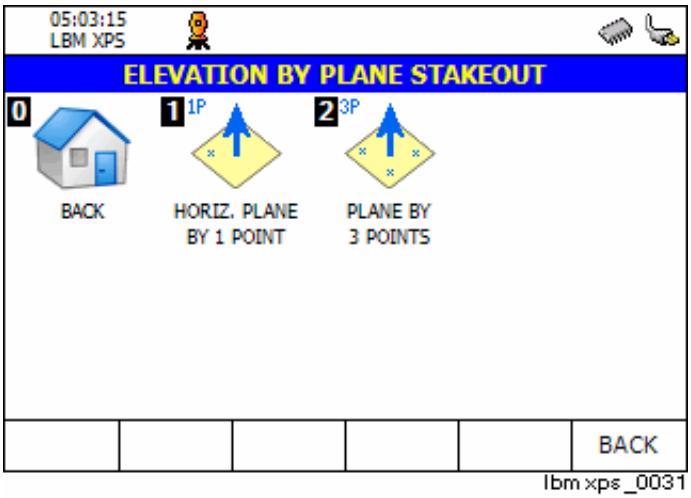
2.3.10. Reference plane stakeout (TPS)

Staking out a reference plane consists of identifying the height of as many points as required to carry out excavations, terrain levelling etc.

Given a reference plane, the program enables the calculation of the height of any point you wish and of the difference between the calculated height and the planned height defined by the reference plane. The selection of the planimetric position of the points on the ground is left completely free and hence it is not required that the station occupies a particular coordinate position.

There are two possibilities to define the reference plane:

- **Horizontal plane:** It is enough to input the height of the instrument, the reflector height and take a measurement to determine the relative height of the station with respect to a benchmark which defines the height of the reference plane;
- **Inclined plane:** It is enough to input the height of the instrument, the reflector height and take three measurements towards three benchmarks which define the heights of the reference plane.



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Before proceeding to the stakeout, 1 or 3 reference points must have been identified on the terrain. The relative three-dimensional coordinates of these points from the station define the parameters which the program will use to calculate the reference plane.

To access the plotting of a reference plane, select the following items in sequence from the active job menu: *Stakeout*, *Elevation by Plane*. Then select the type of plane you wish to stakeout from the menu displayed: whether a horizontal plane (item *Horiz. Plane by 1 Point*) or an inclined plane (item *Plane by 3 Points).*

2.3.11 Horizontal reference plane stakeout

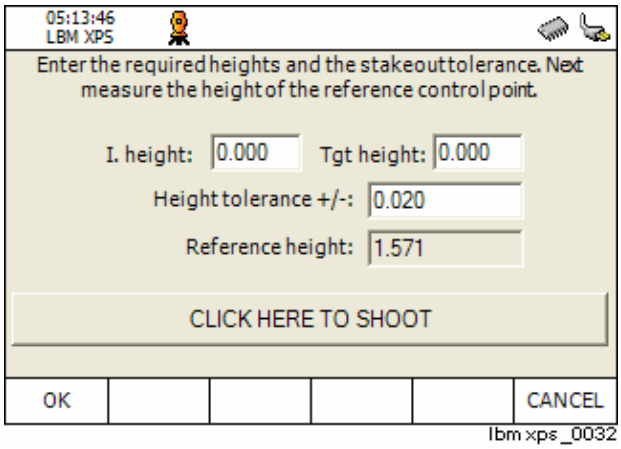
Before proceeding, ensure that you have identified the position of the reference point on the terrain, which defines the height of the horizontal plane to be staked out. If this reference point does not exist you cannot proceed to the staking.

To access the stakeout of a horizontal reference plane, select the following items in sequence from the active job menu: *Stakeout*, *Elevation by Plane*, *Horiz. Plane by 1 Point.*

The program will show a dialogue window where the following must be inserted:

- the height of the instrument (field *I. height*)
- the reflector height (field *Tgt height*)
- the staking tolerance (field *Height tolerance +/-*).

The staking tolerance indicates the maximum difference in height that can exist between the staked out and planned (the height of the horizontal plane) points for the point to be considered correctly identified on the terrain.



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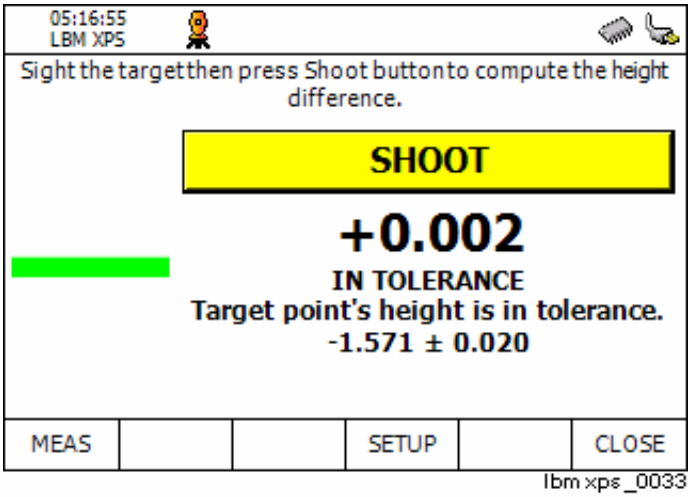
Once the required values have been input, you can proceed to measure the reference point which defines the height of the plane. Aim the instrument at the reference point and then press the *Click here to shoot* button. The program will calculate and display the relative height of the reference point with respect to the station (assumed at height zero); this value indicates the level difference between the station and the reference point and will be used to calculate the reference plane.

To proceed with the stakeout press the *OK* command or press *Cancel* to terminate the operation.

The field survey assistant is free to move around to any point in the area to be staked out. For each point selected, the operator in charge of the program and the total station starts the measurement by pressing the *SHOOT* or *MEAS* button after having aimed at the new reflector position.

On each measurement, the program will show the level difference of the measured point with respect to the horizontal reference plane and a coloured graphical indicator to the left of the screen:

- **Green horizontal bar:** indicates that the level difference lies within the tolerance limits, that is the height of the staked point lies between (–tol + height of the plane) and (+tol + height of the plane);



lbm xps _0033

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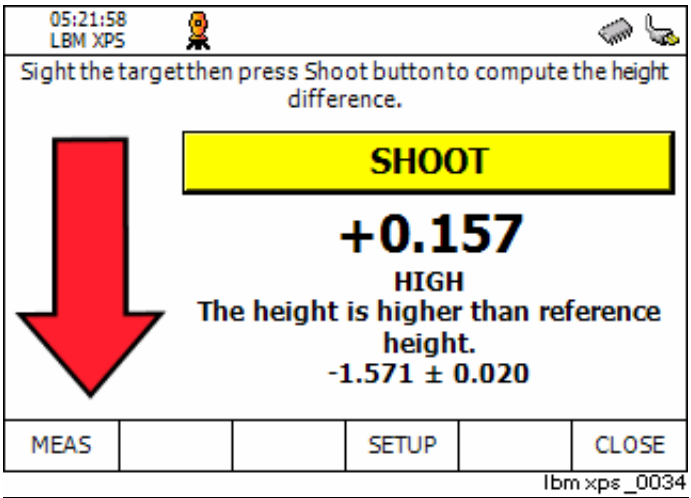
- **Red arrow pointing down:** indicates that the level is not within tolerance limits, that is the height of the staked point is greater than (+tol + height of the plane); it follows that to get the planned height, you must proceed with an excavation as deep as the level difference shown;



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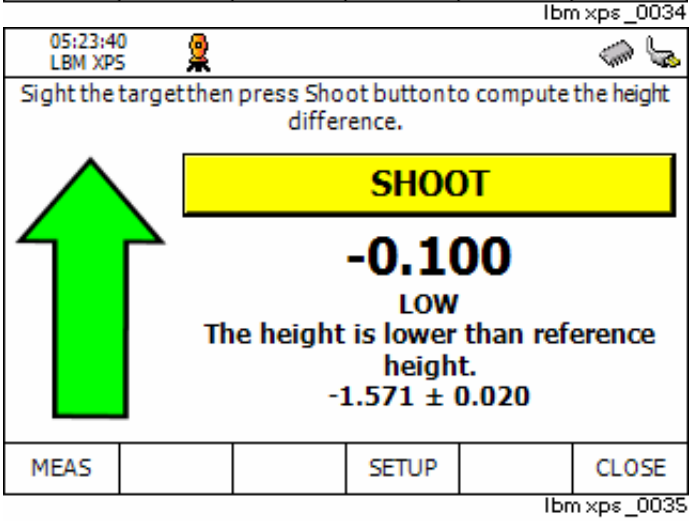
- **Green arrow pointing up:** indicates that the level is not within tolerance limits or that the height of the staked point is less than (-tol + height of the plane); it follows that to get the planned height, you must proceed with a filling as high as the level difference shown, such difference taken as an absolute value (without the sign).



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The height of the instrument, the height of the prism and the tolerance can be modified at any time by selecting the *Setup* command. If the height of the instrument is changed, the measurement has to be taken again towards the reference benchmark.

To terminate the staking phase, select the *Close* command.

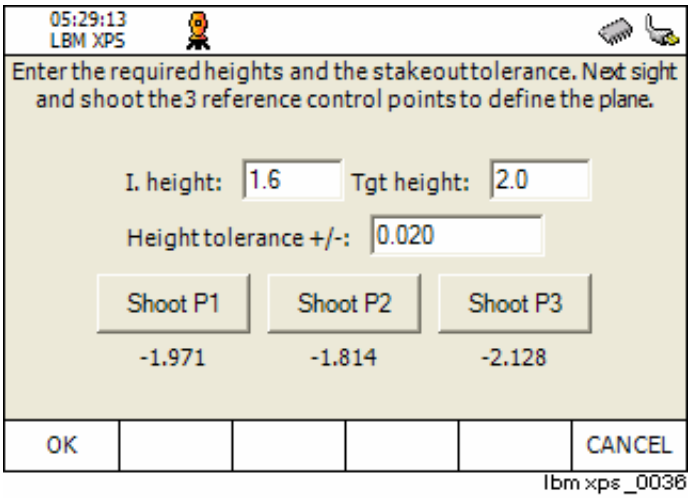
2.3.12. Inclined reference plane stakeout

Before proceeding, ensure that you have identified the position of three reference points on the terrain which define the height of the three points through which the inclined plane to be staked out must pass. If these reference points do not exist you cannot proceed to the stakeout.

To access the stakeout of an inclined reference plane, select the following items in sequence from the active job menu: *Stakeout*, *Elevation by Plane*, *Plane by 3 Points.*

The program will show a dialogue window where the following must be inserted:

- the height of the instrument (field *I. height*)
- the reflector height (field *Tgt height*)
- the stakedout tolerance (field *Height tolerance +/-*).



The staking tolerance indicates the maximum difference in height that can exist between the staked out and planned (at local height of the inclined plane) points for the point to be considered correctly identified on the terrain.

Once the required values are inserted, you can proceed to measuring the three reference points. Aim the instrument at the reference point and then press the *Shoot P1* button. Repeat the procedure for the other two points taking care to press the *Shoot P2* button for one point and the *Shoot P3* button for the other.

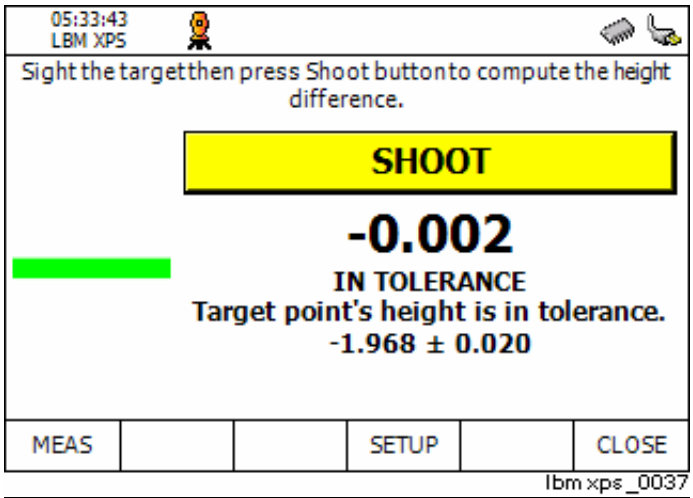
The program will calculate and display the relative height of the reference points with respect to the station (assumed at height zero); these values indicate the level difference between the station and the reference points and will be used to calculate the reference plane.

To proceed with the stakeout press the *OK* command or press *Cancel* to terminate the operation.

The field survey assistant is free to move around to any point in the area to be staked out. For each point selected, the operator in charge of the program and the total station starts the measurement by pressing the *SHOOT* or *MEAS* button after having aimed at the new reflector position.

On each measurement, the program will show the level difference of the point measured with respect to the inclined reference plane and a coloured graphical indicator to the left of the screen:

- **Green horizontal bar:** indicates that the level difference lies within the tolerance limits, that is the height of the staked point lies between (–tol + height from the inclined plane) and (+tol + height from the inclined plane);



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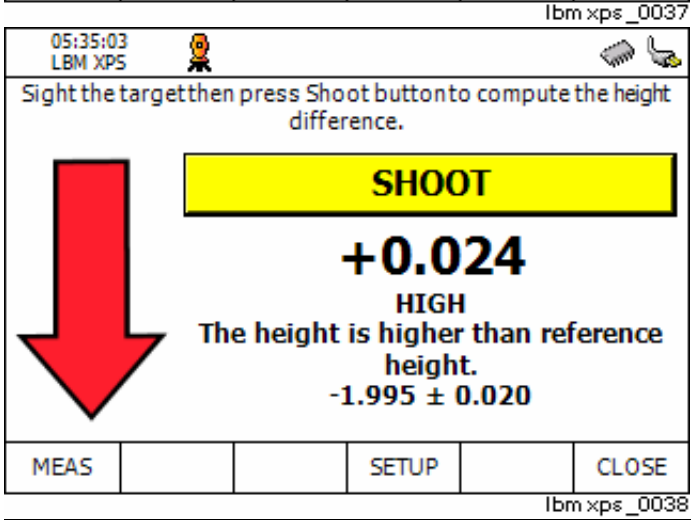
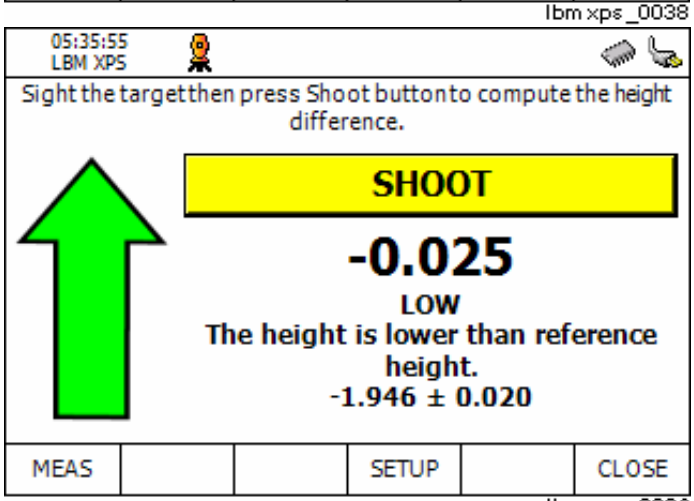
- **Red arrow pointing down:** indicates that the level is not within tolerance limits, that is the height of the staked point is greater than (+tol + height from the inclined plane); it follows that to get the planned height, you must proceed with an excavation as deep as the level difference shown;



lbm xps_0038

- **Green arrow pointing up:** indicates that the level is not within tolerance limits, that is the height of the staked point is less than (-tol + height from the inclined plane); it follows that to get the planned height, you must continue to with filling as high as the level difference shown, such difference taken as an absolute value (without the sign);



lbm xps_0039

The height of the instrument, the height of the prism and the tolerance can be modified at any time by selecting the *SETUP* command. If the height of the instrument is changed, the reference place has to be recomputed by repeating the measurements towards the three reference benchmarks.

To terminate the stakeout phase, select the *CLOSE* command.

2.3.13. Stakeout with GPS

Stakeout by GPS is used to determine the position of points on the ground, if you have their GPS coordinates (latitude, longitude, ellipsoidal height) or their local/map coordinates (east, north, height).

The stakeout program enables to:

- Stakeout the plan points that are stored
  - in the active job
  - in another source job given by the operator
- Optionally store the coordinates of the staked points
  - in the active job
  - in another destination job given by the operator
- Staking out using the reference system
  - WGS84
  - the one defined in the planned points source job
  - the one defined in an external configuration file.

The stakeout can be configured so as to guide the movements of the operator, taking the following as reference:

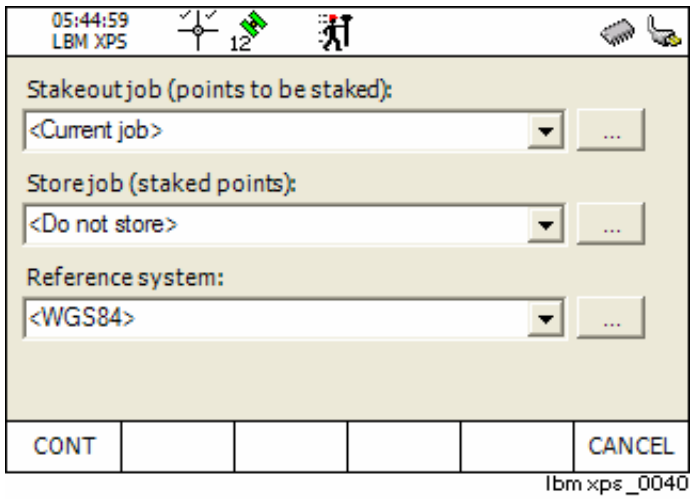
- The North of the reference system
- The last staked out point
- Any point indicated by the operator among those present in the source job
- Any point indicated by the operator among those present in the destination job
- The point to be staked out / the walking direction
- The sun.

Quality controls for the staking out are envisaged. In particular, it is possible to indicate the maximum values of the planimetric distance and height difference beyond which the point is not considered to be precisely staked out.

To further help the operator, the program can be programmed so that it emits a loud warning as soon as the operator comes close to the correct position of the point to be staked out and also that it automatically selects the next point to be staked out among those in the immediate vicinity of the last staked out point.

To start staking out with the GPS, select the following items in sequence from the active job menu: *Stakeout*, *Points*.

2.3.14. GPS Stakeout - Configuration



lbm xps_0040

On starting the GPS stakeout of points, it is necessary to proceed with the configuration which must define:

- The source of the points to be staked
- The destination for the staked points
- The reference system of coordinates.

The **default configuration** of the program, if the operator confirms the first dialogue window displayed without modifying any option, is the following: the source of the points to be staked out, that is the list of **the planned points,** is in the **active job**, the final coordinates of **staked points will not be stored**, the **reference system** is the **WGS84** (the points to be staked out must have valid latitude, longitude and ellipsoidal height geographic coordinates).

Modify the origin of the points: the source file for the planned points, that is the job from which to read the *Point List* to be staked out (point code/number, comment, coordinates) can be specified to the program. The program can be instructed to:

- *Read the points from an external job file:* if the points have been saved in another job, selected the list called *Stakeout job* and select the item *"‹File...›"*. Alternately, press the *[...]* button to the immediate right of the list. The program will display a dialogue window which shows the list of all the jobs stored on the controller. Select the desired job and confirm.
- *Use the existing points in the active job:* It is the default setting.

Modify the destination of the points: the destination file, that is the job to which the *Point List* (point code/number, comment, coordinates,...) must be written after the stake out, can be specified to the program. The program can be instructed to:

- *Store the points in the active job:*
  - if the planned points source file corresponds to the active job, then **the final coordinates of the staked points will substitute the planned coordinates;**
  - if the planned points source file is another job then the final coordinates of the staked points will be stored as new points created automatically by the program and automatically stored in the current job (since the coordinates of the planned points are stored in a job on an external file, they are not changed);
- *Store the points in an external job:* activate the list called *Store job* and select the "*‹File...›*" item. Alternately, press the *[...]* button to the immediate right of the list. The program will display a dialogue window which shows the list of all the jobs stored on the controller. Select the desired job and confirm; remember that:
  - if the planned points source file corresponds to the destination job, then **the final coordinates of the plotted points will substitute the planned coordinates;**
  - if the planned points source file does not correspond to the destination job, then the final coordinates of the staked points will be stored in new points created automatically by the program and stored in the specified external job (since the coordinates of the planned points are stored in the active job or in a different job file, they are not changed);

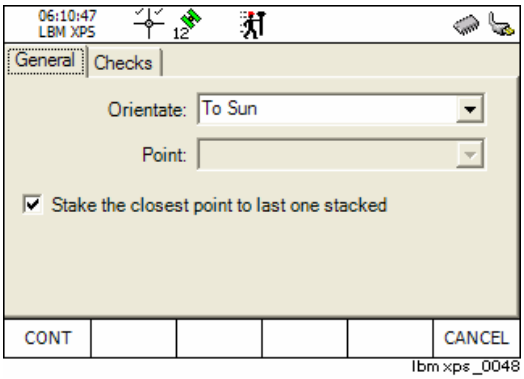
- *Not store the points:* it is the default option; the points that are already staked are not stored, virtually losing any possibility of demonstrating that the final coordinates of the staked points are correct and/or lie within the precision parameters requested by the client.

Modify the reference system: the reference system of coordinates to be used in the stakeout phase can be specified in the program:

- *WGS84*: uses the geographic coordinates (latitude, longitude and ellipsoidal height); the planned points coordinates must be expressed in the same reference system; planned points that have only local/map coordinates cannot be staked out;
- *The same system used in the source job of the planned points:* considering that the source job/file can be either the active job or a stored external job, the parameters of this system are read from the source file and used in the staking phase; this means that the source job contains an active reference system calculated with the proper functions (see *Definition of the GPS Reference System*); the planned points cannot be staked out if the source file does not contain the definition of a reference system;
- *Reference system from a GRR file:* the program allows to store the parameters that define a reference system in a GRR file and this file can be loaded onto a new job to carry out a survey or specified in the staking phase (See *Definition of the GPS Reference System*); in both cases, a "pre-calculated" reference system of coordinates is used.

When the configuration options mentioned above are set, press the *CONT* button to continue or press the *Cancel* button to exit from the stakeout program.

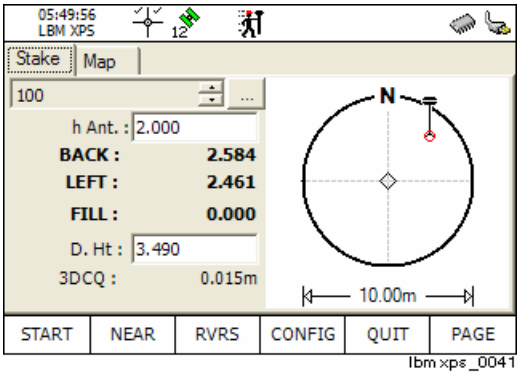
2.3.15. GPS Stakeout – Orientation and Verifications



lbm xps_0048

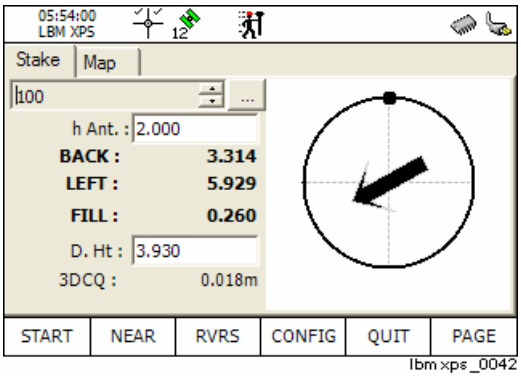
The definition of the *reference orientation* and the *verification of the quality of the coordinates* is the second part of the stakeout configuration. This part of the configuration can be modified at any time during the stakeout phase by simply pressing the *CONFIG* command.

The GPS stakeout can be configured (changing the *Orientate* option) so as to guide the movements of the operator, taking the following as reference:



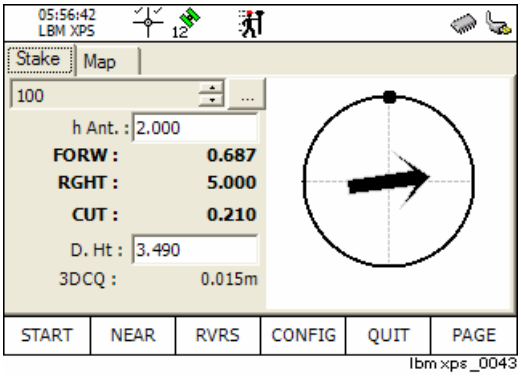
lbm xps_0041

- **TO NORTH - The North of the reference system:**
  - If the reference system of coordinates is the WGS84, the North of the reference system approximately corresponds to the magnetic North; then the operator can "look towards the geographic/magnetic North", perhaps with the help of a magnetic compass, and follow the movement directions given by the program;
  - If the reference system of coordinates is not the WGS84, the North of the reference system must be noted previously; then the operator can "look towards the North" of this reference system and follow the movement directions given by the program;



lbm xps_0042

- **TO LAST POINT - The last point staked out:**
  - If a point has been staked, the operator must "look towards this point" and follow the movement directions given by the program;
  - If a point has not been staked, the program uses the North of the reference system as the direction of reference;



lbm xps_0043

- **TO POINT (STAKE) - Any point specified by the operator among those present in the source job:** From the drop down list called *Point*, select the point code/number of the point to be used as reference; the operator must "look towards this point" and follow the movement directions given by the program; the selected point must have coordinates that are compatible with the active reference system of coordinates;

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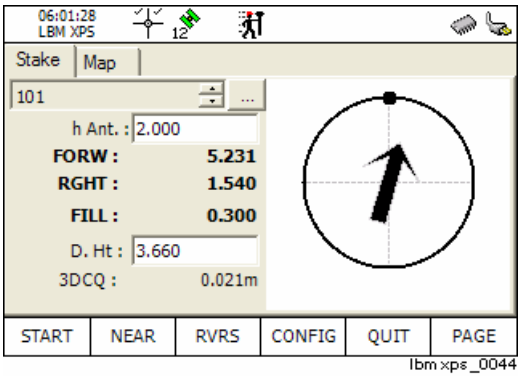
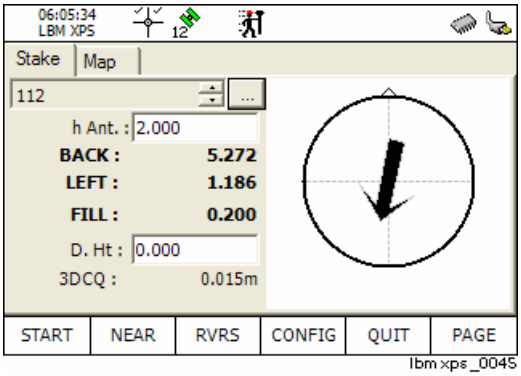
- **TO POINT (STORE) - Any point specified by the operator among those present in the destination job:** From the drop down list called *Point*, select the point code/number of the point to be used as reference; the operator must "look towards this point" and follow the movement directions given by the program; the selected point must have coordinates that are compatible with the active reference system of coordinates;



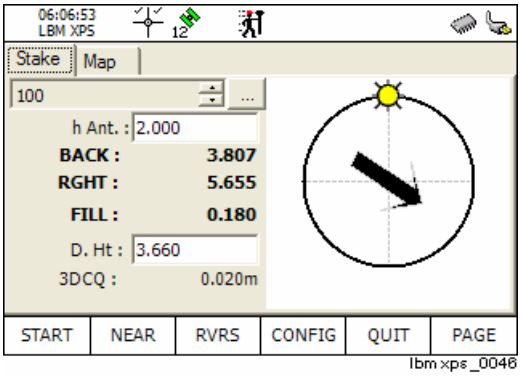
lbm xps_0044

- **TO ARROW - The point to be staked out / direction of the movement:** The program continuously calculates the operator's movements and provides information on which direction to follow in order to come close to the point to be staked out; hence, the operator needs only to follow the instructions shown on the screen taking care not to stop otherwise the program cannot calculate the direction of the point to be staked out precisely (the longer the operator waits, the less reliable the precision of the information);



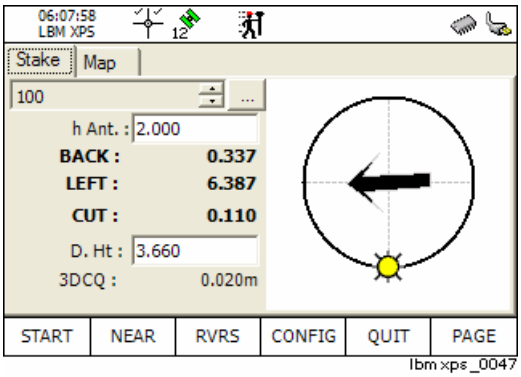
lbm xps_0045

- **TO SUN - The sun position:** The program can calculate the position of the sun using the current latitude and longitude; using this position and the coordinates of the point to be staked out, the program calculates the movement directions; the operator must "look towards the direction of the sun" and follow the movement directions given by the program.



lbm xps_0046

The operator can "turn around" at any time, for example to avoid exposing the controller display directly at the sun light, to avoid the risk of looking at the blinding sun or to use his own shadow as an indication of the sun direction. In this case, the program must be informed by pressing the *RVRS* button. The program will display the movement directions considering that the operator is now turned around: for example, in the mode referring to the sun direction, the icon of the sun will be moved in the lower part of the direction indicator, all the directions will be inverted, that is, if it was FORW it becomes BACK and vice versa, LEFT becomes RIGHT and vice versa, the orientation of the arrow which shows the movement direction to follow will consequently be modified.



lbm xps_0047

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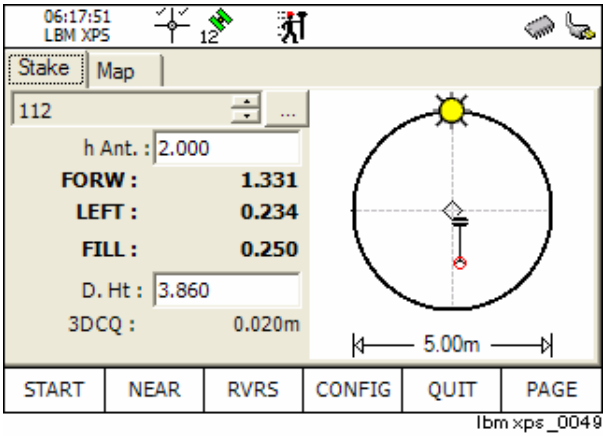
The length of the path to be followed to stake the planned points can be optimized (reduced) by instructing the program to select one of the nearest points (among the points to be staked out) according to two operational modes:

- **Point closest to the last staked point:** by activating the corresponding option in the configuration dialogue (press *CONFIG*, enable the *Stake the closest point to last one staked* option);
  this informs the program that, when a staked point is confirmed, it must automatically choose another point, among the ones to be staked, closest to the point which was just staked;

- **Point closest to the current position**: by pressing the *NEAR* command;
  the activation of this command forces the program to select the point, among the ones to be staked, closest to the current rover position.

As soon as the operator, on following the instructions given on screen by the program, brings the rover close to the point to be staked, at a distance of less than 5 meters, the graphical indications vary:



lbm xps_0049

- The arrow showing the direction vanishes and a schematic design of the rover (pole with antenna) appears in its place inside the circular indicator so that it gives an overview of the distance of the rover from the point to be staked;
- In the lower part, the diameter of the circular area appears; this diameter is automatically updated and can assume the following values based on the distance of the rover from the point to be staked: 0.25m, 0.5m, 1.0m, 2.5m, 5.0m;
- The movement directions FORW/BACK and RIGHT/LEFT refer to the active orientation system: that is, the operator must in any case continue to follow these directions "always looking towards" the reference direction selected using the configuration dialogue (which can be accessed by pressing the *CONFIG* button).

If the corresponding option has been activated (the option can be accessed by pressing the *CONFIG* button, *Checks* page, option *Beep near point),* the program will emit an acoustic signal (repetitive) as soon as the operator brings the rover within a range less than or equal to the set maximum range from the point to be staked out. The emission of the acoustic signal terminates as soon as the operator distances the rover from the point to be staked out beyond the maximum distance set.

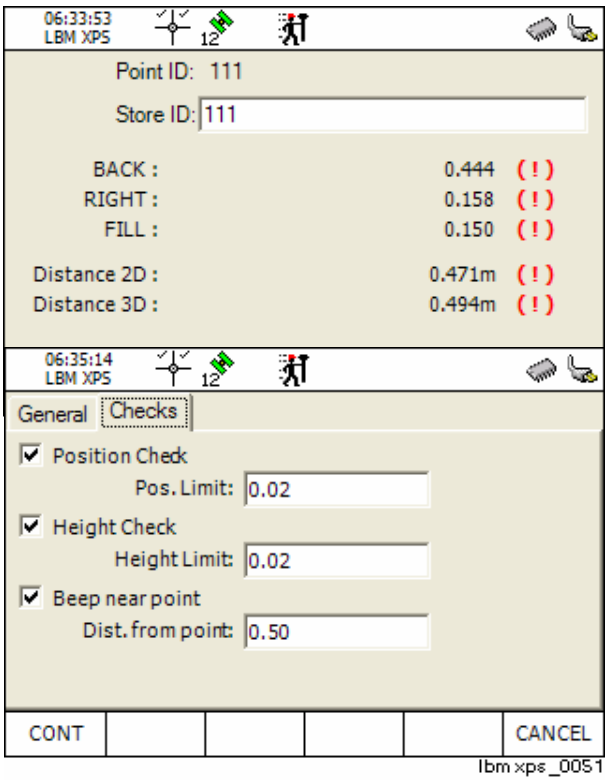
Having reached the point to be staked out, or when the values of the distances (FORW/BACK, RIGHT/LEFT) have reached values that are acceptable based on the required precision set for staking, the operator must:

- Verify that the height of the antenna (phase center) is correct;
- (Optionally) enter the planned height in the *D. Ht* (design height) field: if the value specified, read from the coordinates of the points to be staked out does not exist or if it needs to be changed (for example if the client has provided a design that requires that the points to be staked out are "raised" by a delta value to achieve the final point heights, which define the height of the area to be filled with other material);
- Verify that the pole on which the antenna is mounted is vertical;

- Press the *START* command to proceed to the phase which precisely acquires the coordinates of the point; the icon on the upper part of the screen, the "walking man figure" changes into an icon that shows a "standing man figure" and a tripod with an antenna to graphically indicate that the operator must not move the rover except to adjust his planimetric or altimetric position a little.
- Verify that the 3D CQ is acceptable (precision indicator of the coordinates in the acquisition phase, expressed in meters);
- Press the *STOP* command to terminate the acquisition of the coordinates.

After pressing the *STOP* command, the program will show a dialogue window which gives information on the precision of the coordinates acquired and also allows the staked point to be stored:

- The absolute error between the planned and staked planimetric coordinates (FORW/BACK and RIGHT/LEFT directions);
- The absolute error between the planned and staked heights (FILL/CUT directions);
- The planimetric distance between the planned and staked point (*Distance 2D* indication);
- The inclined distance between the planned and staked point (*Distance 3D* indication).



lbm xps_0051

If any one of the plotting precision verification options are active and even if one of the absolute errors is greater than the limit values set in the options, the point cannot be saved and the values beyond the tolerance values will be highlighted with a red exclamation mark in parentheses. In this case, the operator has the following options:

- Press the *BACK* button to re-stakeout the point;
- Press the *SKIP* button to proceed with the staking out of another point; if the option to automatically suggest the next point to be staked out is active, the program will automatically suggest the point that is closest to the point which has been skipped, otherwise the operator must manually select another point to be staked out or press the *NEAR* button to request the automatic selection of the closest point.

If the staking precision verification options are disabled, or the absolute errors of the just staked point coordinates are within tolerance limits, the operator has the same options as above plus the option to store the staked point.
The store command is disabled if, in the configuration phase, the operator has specified that he does not want the staked out points to be memorized.

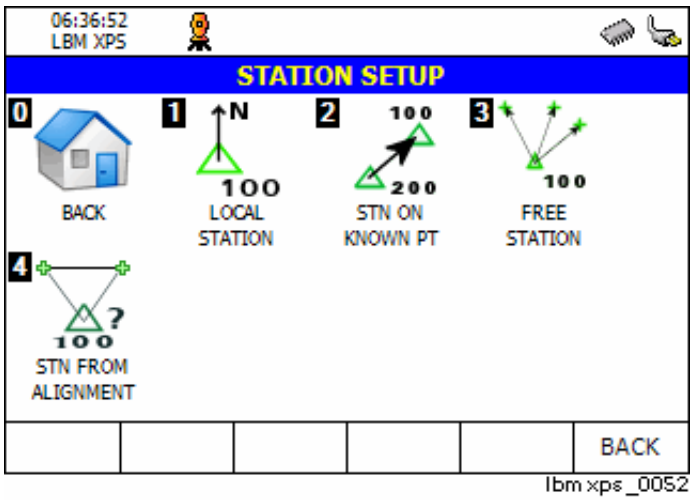
To proceed with the storing of the staked point:

- Specify the point code/number to be assigned to the staked point in the *Store ID* field; the program automatically suggests the same point code/number as the planned point;
- Press the *STORE* button;
- If the point code/number is already present in the destination job, the program will request a confirmation before overwriting it.

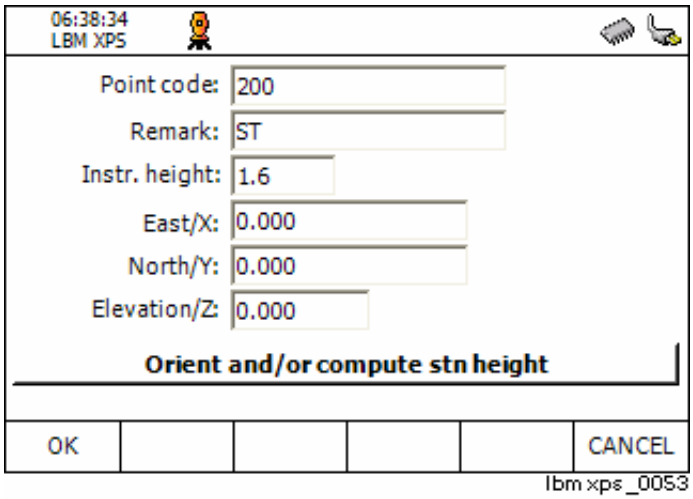
If the option to automatically suggest the next point to be staked out is active, the program will automatically suggest the point that is closest to the point which has just been stored, otherwise the operator must manually select another point to be staked out or press the *NEAR* button to request the automatic selection of the closest point.

To exit the stakeout program press the *QUIT* button and input *Yes* on the request to confirm the exit.

2.4 Station setup (TPS)



lbm xps_0052



lbm xps_0053

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East/X and *North/Y*: coordinates to be assigned to the point/station, mandatory.

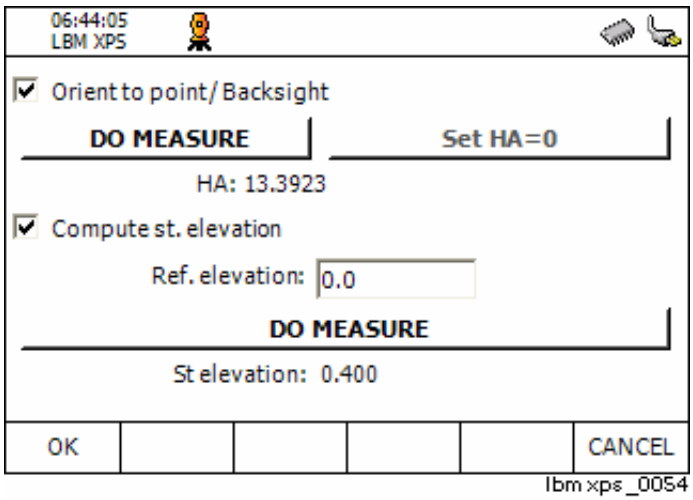
Elevation/Z: height of the point/station, required only if altimetric surveys are carried out.

If you do not wish to orientate the station and/or calculate its height with respect to a benchmark, the station set up operation can be terminated, otherwise read further.

Press the *OK* command to confirm the non-orientated station set up, or press *Cancel* to avoid setting up the station.

2.4.2. Orienting the local station and calculating the height

The station can be oriented by measuring a previously determined reference point on the ground (the coordinates of this point need not be known). Additionally, the height of the station can be calculated by measuring a previously determined reference point on the ground whose height is known, usually a fixed point used as altimetric reference for all the surveys conducted in the area.



lbm xps _0054

If you wish to orientate the station and/or calculate its height, press the *Orient. and/or compute stn height*. The application will show a dialogue window which enables the two operations to be executed.

To orient the station activate the *Orient to point/Backsight* option, aim at the orientation point and then press the *Do measure* button (the button on top) to acquire the angle. If you wish to force the angle to zero in the direction of the orientation point, press the *Set HA=0* button after aiming at that point.

To calculate the station height with a known reference point height, activate the *Compute st. elevation* option, insert the height of the point in the *Ref. elevation* field, aim at the reference point and then press the *Do measure* button (button at the bottom). The program will calculate and display the height of the station obtained by the measurement. To allow the calculation of the height, the instrument height (previous dialogue window) and the reflector height (requested later by the program) must have been specified.

To confirm the station set-up press the *OK* command, or press *Cancel* to cancel.

2.4.3. Station on an existing point or Next traverse station (TPS)

A station on an existing point (or next traverse station) is set up in one of the following cases:

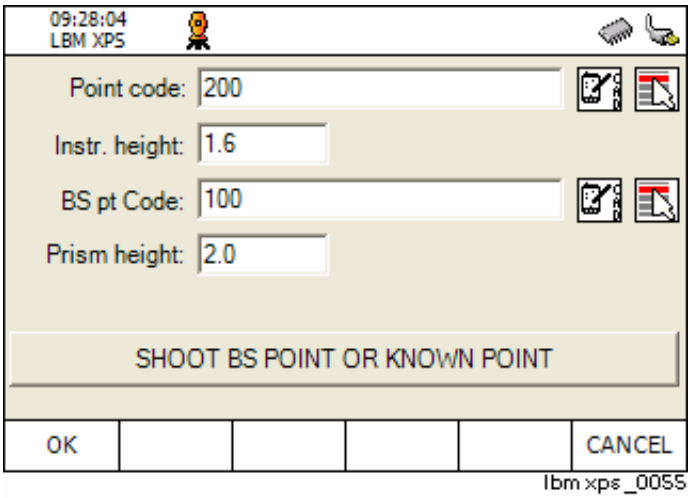
1. A survey is being carried out and the station is to be set up on a point surveyed by a preceding station then orienting the instrument towards such preceding station point or towards a point measured by such preceding station;
2. The station is to be placed on an existing point, previously identified on the ground (post, nail etc.), orienting the instrument towards another existing point already identified on the ground; the existing points are already present in the *Point List*.

In the first case, the station set-up is "linked" to the previous one: this is the typical case of a survey where, in order to cover the area, the instrument must be placed in different points to form a traverse or a grid.

The second case falls under the first only if both the station and the orientation points originate from previous stations or are calculated from measurements taken by one or more preceding stations. Otherwise, a station that is "partially linked" or "totally unlinked" to the rest of the survey is set up (but keeping uniformity in the reference system of coordinates used).

A station is "partially linked" when the station point or the orientation point, one excluding the other, is calculated from measurements taken by a preceding station. In this case the modifications of the coordinates or the measurement of a preceding station can cause the moving of or a variation in the orientation of the new station set up.

A station is "totally unlinked" if the station point and the orientation point have fixed coordinates which are not dependent on prior measurements. In this case, modifications to the coordinates and/or the measurements of a preceding station have no effect on the new station set up, the position or the orientation of which will not change.



In both cases the station set up procedures are identical.

To start setting up a station on an existing point (or next traverse station), select the items *Station Setup*, *Stn on Known Pt* in sequence from the active job menu.

A dialogue window will ask to input the following data:

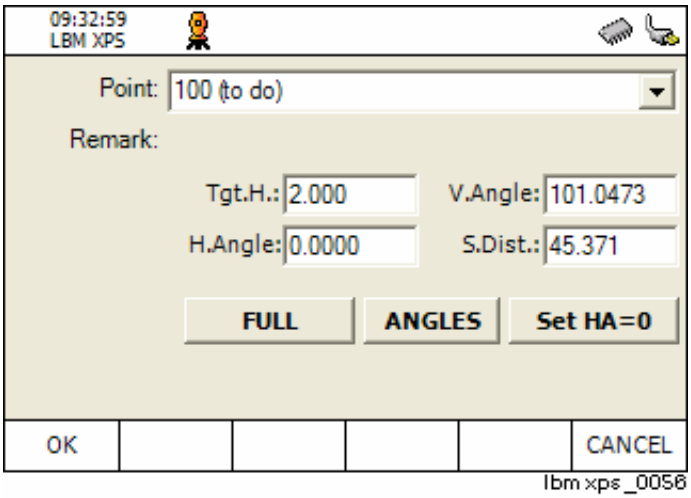
Point code: a point code/number which univocally identifies the station and the point on which it is set up. The procedure will NOT automatically generate a univocal point code/number since in this mode the point must already exist. Write the point code/number or select it by using the two buttons to the right of the field (*select from CAD* and *select from Point List*).

Instr. height: height of the instrument, required only if altimetric surveys are carried out.

BS pt Code: a point code/number which univocally identifies the existing point towards which the station is to be oriented (backsight). Write the point code/number or select it by using the two buttons to the right of the field (*select from CAD* and *select from Point List*).

Prism height: height of the prism for the next measurement of the station orientation. It is required only for altimetric surveys.

After defining all the above parameters, the station must be oriented: This is equivalent to reset (virtually, read further) the angle of the instrument so that the zero corresponds to the direction of the orientation point. In reality, even if it is possible, it is not necessary to reset the horizontal angle of the instrument: the procedure will use an angle measured during the orientation as a substitute, that is, it will subtract this value from all the subsequent measurements taken by the station to obtain the real angle with respect to the orientation.



lbm xps_0056

To start the orientation of the station, press the *Shoot BS Point or Known Point* button. The program will show a dialogue window to take the orientation measurement. Aim the instrument at the orientation point, then press the *FULL* button to take the complete measurement, or press the *ANGLES* button to take the measurement of only the angles.

If the station being set up falls under the case called "linked station" (the station is on a point surveyed by a previous station and the orientation measurement is towards the previous station) and a complete measurement is taken (distance, vertical and horizontal angles), then the program will use the horizontal distance and the horizontal distance by the corresponding measurement from the previous station towards the new one to calculate the average distance. This distance will be used to determine the coordinates of the station being set up. Otherwise the coordinates of the station being set up will be those of the point with the same name/number of the point existing in the *Point List* (coordinates calculated by a previous station or imported from a file or inputted manually by the operator).

To confirm the station set-up press the *OK* command, or press *Cancel* to cancel.

2.4.4. Free Station – Resection (TPS)

In cases when the instrument cannot be placed on an existing point (or in cases where the position of a point on the ground has not been previously marked with a nail, post etc. or it has been *removed*) and there are at least two valid points available (points with valid coordinates), then by using at least two points in the *Point List* which are already determined on the ground, the station set up can be started, the station being calculated by measurements towards existing points: the *free station*, also known as *resection.*

Before proceeding with the station set up, it is best to verify that the existing points have already been inserted in the *Point List* and that the coordinates of these points are correct.

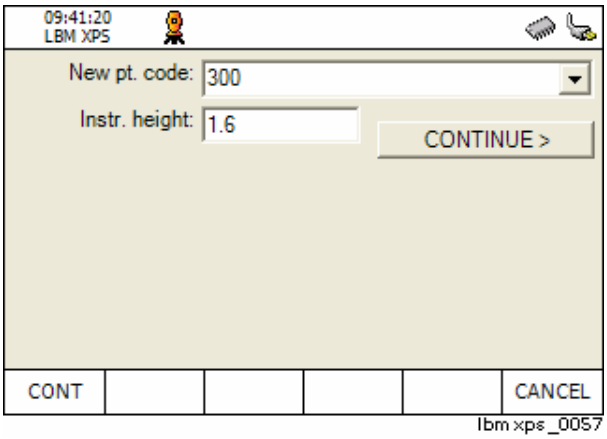
To start setting up a free station, select the following items in sequence from the active job menu: *Station Setup, Free Station*.

The set up of the free station consists in the following operations:

- *Definition of the station data:* the first dialogue displayed requires the input of a univocal point code/number to associate with the station and the point to be occupied. The procedure automatically generates a univocal point code/number which can be modified.

  Specify the height of the instrument if the height of the station must be calculated. In this case, the existing points which will be measured must also have height values. Leave the field empty if the height need not be calculated.

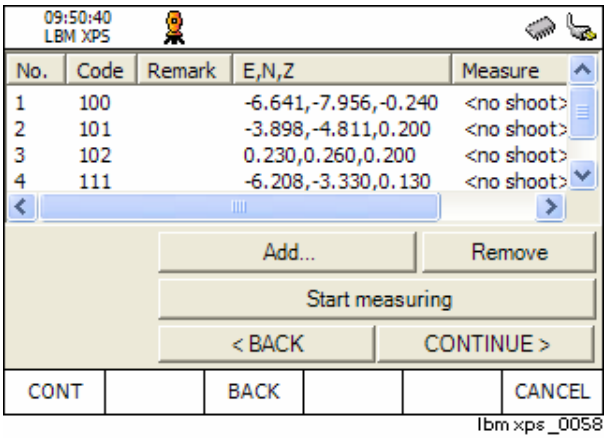
  Press the *CONT* button to proceed.



lbm xps_0057

- *Selection and measurement of the existing points:* the second dialogue window displayed requires that the points used to calculate the station coordinates be specified. Use the *Add* button to add points to be measured and the *Remove* button to remove the point selected from the added ones.

  After defining at least two existing points, press the *Start measuring* button to enter the measurement phase.



lbm xps_0058

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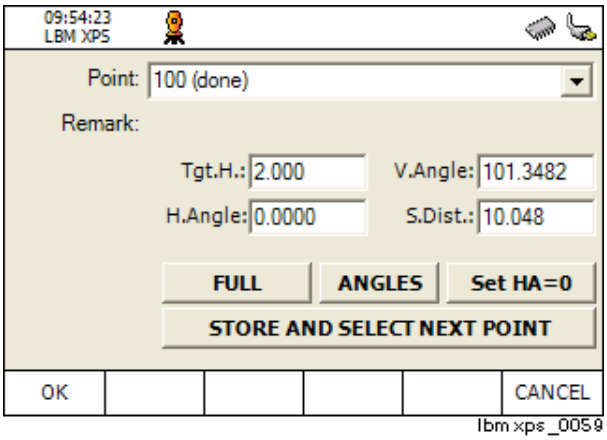
- A dialogue window will enable all the measurements towards the selected points.

  Using the drop down list select the points and perform all the individual measurements. Press the *Store and Select next Point* button to store the individual measurements.

  Close the measurement window to return to the previous window.

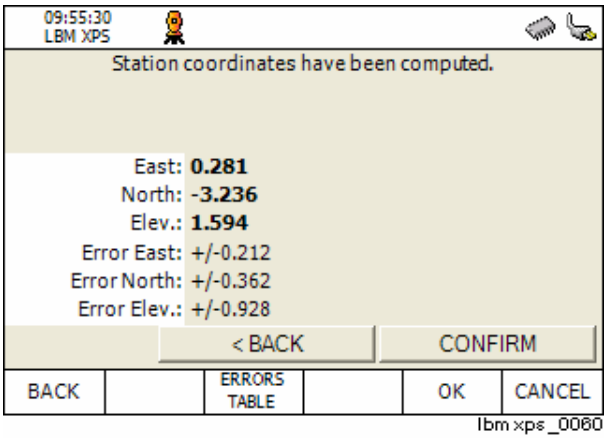
  At the end of the measurements, press the *Continue* button to proceed with the calculation.



lbm xps_0059

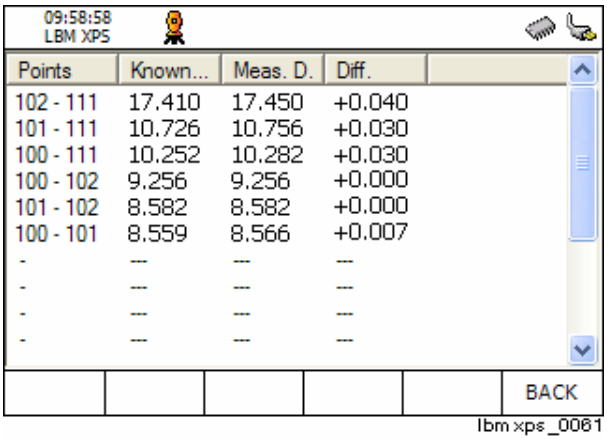
- *Calculation of the station point coordinates:* the calculation of the coordinates from the measurements towards the existing points is completely automatic. The procedure selects the most suitable calculation method based on the number of points measured.

  If the calculation is successful, the procedure displays the coordinates which will be assigned to the station. In case the calculation is not successful, the procedure will display an error message.



lbm xps_0060

  The differences between the distances calculated between pairs of existing points (distances from the coordinates in the *Point List*) and the corresponding calculated distances from the measurements can be displayed by pressing the *Errors Table* command.

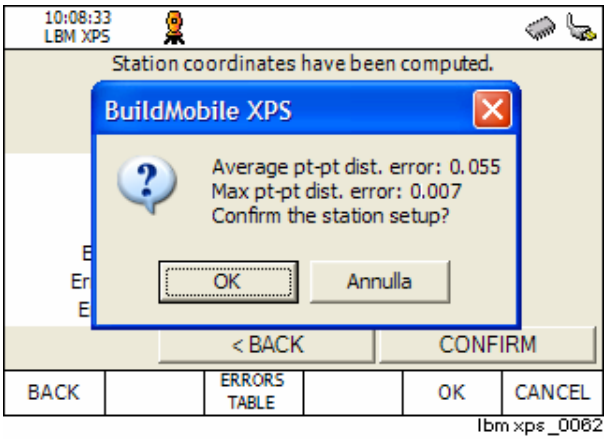


lbm xps_0061

Then press the *Confirm* or *OK* button to confirm the station set up. To return to the dialogue window containing the selection and measurement of the existing points, press the *Back* button.

If the *Confirm* or *OK* button has been pressed, the application will show an additional confirmation request which gives the average error and maximum error detected between the existing point pairs.

Evaluate whether the average error and the maximum error are satisfactory and if so, press the *OK* button to definitely confirm the station set up. If not press the *Cancel* button to return to the calculation results page (and to the previous screens from here). Then verify the factors which determine the significant differences (incorrect coordinates for existing points, inaccurate measurements, reflector not in vertical position, etc.).



lbm xps_0082

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2.4.5. Station by alignment

In case the instrument must occupy any one position on the ground and simultaneously an alignment must be defined by measuring two previously identified reference points (marked on the ground with posts, nails or others), the station can be set up with the *alignment* method.

This type of set up is indicated in cases where it is desired to proceed to *positioning the nails on the batter boards* or to stakeout points (by distance and offset).

A condition necessary to use this type of station set up is that the ***job must be completely empty.***

The application prevents the set up of an alignment station if the job is not completely empty so that, given the totally "local" nature of the coordinates assigned to the station, points which belong to a reference system different from the rest of the survey already in the memory are not acquired.

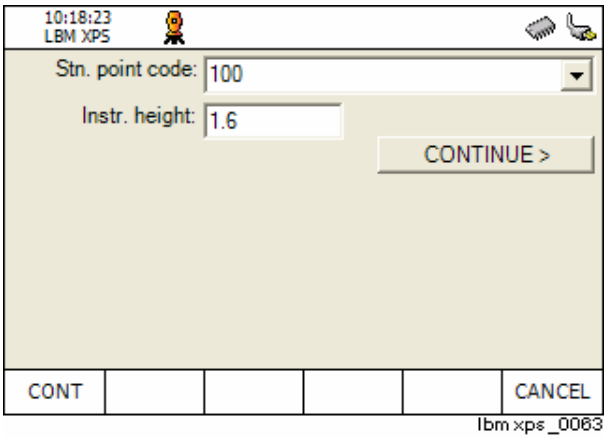
To start setting up a station by alignment, select the following items in sequence from the active job menu: *Station Setup*, *Stn from Alignment*.

The set up of the station consists in the following operations:

- *Definition of the station data:* the first window displayed requires the input of a univocal point code/number to associate with the station and the corresponding point to be inserted in the *Point List*. The procedure automatically generates a univocal point code/number which can be modified.

  Specify the height of the instrument if the heights must also be calculated. Leave the field empty if the heights need not be calculated.

  Press the *CONT* button to proceed.



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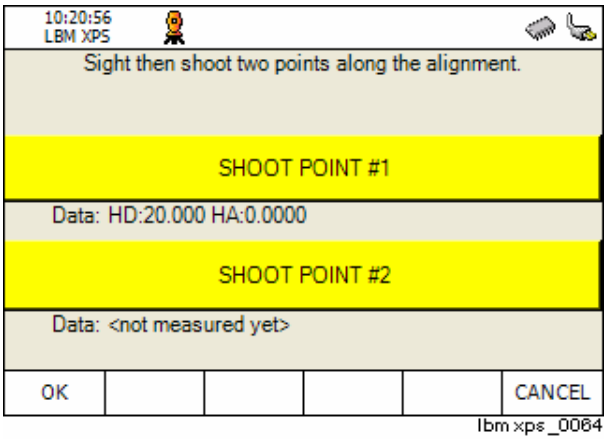
- *Measurement of two points to define the alignment:* the second dialogue window displayed enables the measurement towards the two reference points for the alignment (i.e. the principal alignment used in the different functions of the program).

  Take the measurements specifying a point code/number (automatically assigned and modifiable), a comment and prism height when requested.

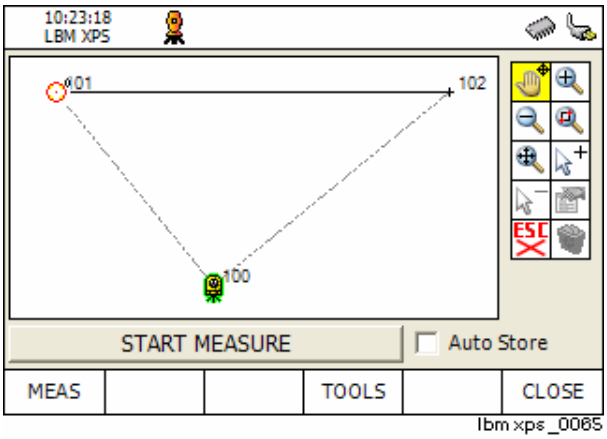
  The station set up terminates immediately after the measurement of the second point.



lbm xps_0084

- The two points measured in this way will be inserted into the *Point List* and will have coordinates (calculated automatically) so as to place them aligned in the West › East direction.

  A station with the two measurements will also be created and inserted in the *Field book*.



lbm xps_0085

The station point will have coordinates (automatically calculated) so as to guarantee that the coordinates of the two points measured, recalculated using the measurements in the *Field book* correspond to the coordinates assigned automatically to place the alignment in the West › East direction.

To facilitate the graphical determination of the alignment defined in this manner, the program also automatically creates a segment which unites the two points measured (access the CAD view or enter in survey mode manually).

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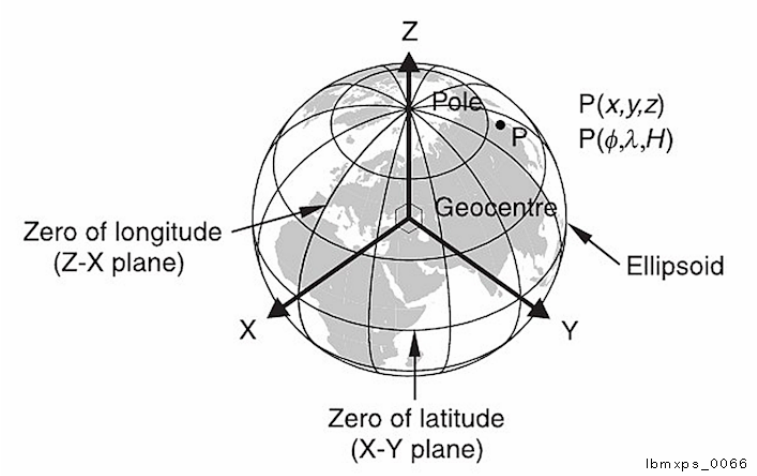
2.4.6. Definition of the GPS reference system



The GPS positioning system uses a reference system called *WGS84*, an acronym of *World Geodetic System 1984*. The *WGS84* is a complex system; as its discussion is beyond the scope of this manual, we will limit ourselves to enumerating the characteristics of practical interest:

- The spatial coordinates processed by GPS are expressed with the X,Y,Z values which refer to a tri-dimensional Cartesian system of coordinates, whose origin is the centre of the earth, the Z axis passes through the North Pole and the X-Y plane coincides with the equatorial plane: the ECEF (Earth Centred Earth Fixed) coordinates*;*
- The X,Y,Z spatial coordinates can be easily converted to (or obtained from) an equivalent values called latitude, longitude and ellipsoidal height: the geographic coordinates (two angles and an height).

In practice the geographic coordinates are preferred since they refer to a well defined tri-dimensional geometric figure: the reference ellipsoid. The reference ellipsoid is a mathematical surface which is close to the geoid, the true shape of the Earth.

A local reference system (local plane), or one or more national coordinate systems (datums), is used during surveys or while staking out; from here on in the manual, these systems will be called local system or local reference system and the coordinates expressed in these systems will be called local coordinates. A point whose coordinates are expressed in a local system will be called a local point.

Additionally, to take mixed surveys which are partly done with Total Station and partly with GPS, it is very important that the GPS coordinates, both ECEF and geographic, can be transformed into the same local reference system used with Total Station.

In this manual, the operation which permits the calculations of the parameters to transform GPS coordinates to the corresponding local coordinates is specified as creation (or definition) of a reference system.

The program allows the calculation of the transformation parameters if the East and North coordinates, as well as the height of some local points and the corresponding GPS coordinates are available. The GPS coordinates can be previously determined or surveyed in real time.

Two cases are distinguished based on the number of points (in local coordinates) used:

- A single point in local coordinates *east, north, height*: Local system from a point;
- Two or more points in local coordinates *east, north, height*: Local system from GPS resection.

See:

- Local System given a point
- GPS Resection.

2.4.7. Local system given a point (GPS)

The program allows to activate a transformation from the *WGS84* reference system to a local reference system in *east, north, height* coordinates by performing a simple GPS measurement on the point whose *e, n, h* coordinates are known.

The local system will have the following characteristics:

- The origin of the coordinates 0,0,0, corresponding to the GPS point;
- Cartesian axis system with a 1:1 scale having
  - the ordinate axis oriented in the South-North direction (a "parallel" of the *WGS84* ellipsoid);
  - the axis of abscissas oriented in the West-East direction (a "meridian" of the WGS84 ellipsoid).

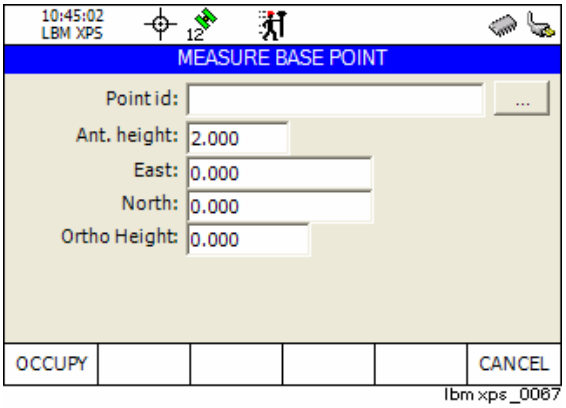
The origin of the coordinates can be varied by modifying the automatically suggested values or by instructing the program to use the coordinates of a point that is already inserted in the *Point List* (one which has valid local coordinates).

The local system defined in this manner cannot be used to stakeout points having coordinates computed by another local reference system even if the other reference system was calculated using the same procedure.

On the other hand the following can be done:

- Stakeout points in WGS84 coordinates;
- Stakeout points in local coordinates if these were previously acquired using the same reference system;
- Stakeout points in local coordinates obtained through COGO calculations on points acquired previously using the same reference system.

To start the definition of the local system from a point, select the following items in sequence from the active job menu: Reference System, 1Pt GPS Resection. The application will show the dialogue window *Measure Base Point* for the insertion of the data necessary for the calculation:



- Point id: to be inserted only in case the east, north and height coordinates must be copied from a point present in the *Point List*; in this case enter the point code/number or press the *[...]* button to select the point from the *Point List*;
- *Ant. height*: height of the GPS antenna (phase center);
- *East, North and Ortho Height*: local coordinates of the reference point.

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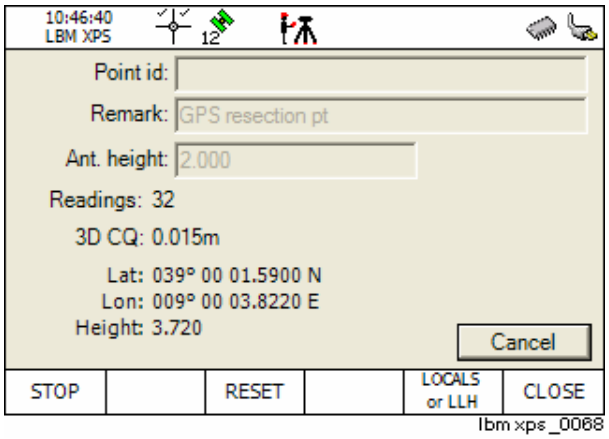
Insert the required values or press the *Cancel* button to end the operation.

Occupy **the point corresponding to the local coordinates inserted** with the GPS, verify that the pole is in a perfectly vertical position and then start the acquisition by pressing the *Occupy* button: The program will show a dialogue window which displays the progress of the GPS coordinate acquisition.

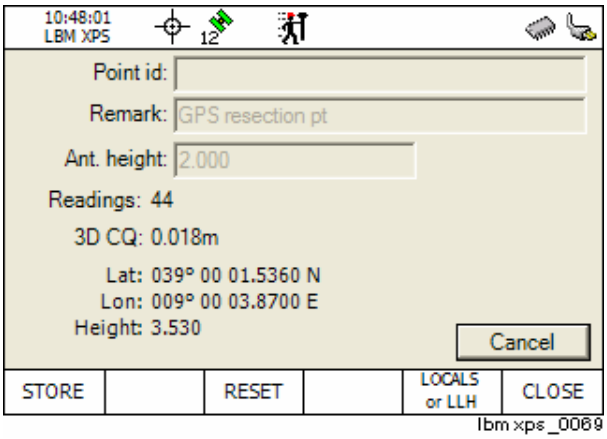


During the acquisition phase, the following are displayed and updated continuously on the screen: the number of readings taken, the 3D CQ value and the current geographic coordinates.

When the 3D CQ value (quality of the coordinates, gives the estimated error of the current GPS position in meters) rests at a value which is not very high (typically 1-2 centimeters or millimeters) press the *Stop* command.

If the GPS could calculate the coordinates (latitude, longitude and the ellipsoidal height), the *Store* command will show instead of the *Stop* command.

The acquisition can be re-executed by pressing the *Reset* button and then pressing the *Occupy* button which will be displayed instead of the *Store* command. Alternatively, if the acquisition of the point must be abandoned then press the *Close* button.



Press the *Store* button to exit from the GPS coordinate acquisition window: the program will request a confirmation to activate the local reference system calculated in this manner:

- if the request is not confirmed, the program returns to the initial dialogue window (for the input of the data required for the calculation);
- on confirming the request, the program returns to its main menu.

2.4.8. GPS Resection

The generic term *GPS resection* refers to the operation which enables the creation of a reference system given the local *e, n, h* coordinates of **at least two reference points**, and by executing (or having already executed) **as many other GPS measurements on the same points**.

GPS resection is hence an operation which enables the calculation of the transformation parameters necessary to determine the local coordinates corresponding to the GPS coordinates.

Unlike the local reference system given a point (see the previous paragraph), the reference system calculated with the GPS resection allows:

- **To maintain the orientation of the original local coordinate system** in which the reference points coordinates are expressed;
- **To maintain the scale factor of the original local coordinate system** in which the reference points coordinates are expressed.

The above is valid for planimetric coordinates. The following is valid for the heights:

- If none of the reference points in the local coordinates specify the height then the reference system will maintain the ellipsoidal height;
- If one of the points among the reference points in the local coordinates specifies the height then the reference system will convert the ellipsoidal height into the local height setting the correction to the difference between the local height of the point and the corresponding ellipsoidal height measured via GPS (undulation);
- If more than one point among the reference points in the local coordinates specifies the height then the reference system will convert the ellipsoidal height into the local height setting the correction to the average of the differences between the local height of the points and the corresponding ellipsoidal heights measured via GPS (average undulation).

If in the calculation phase of the GPS resection only one local point is specified then the application will behave as described already in the previous paragraph *Local System given a point*.

Using the GPS resection to activate a local reference system allows to execute the following operations:

- survey of points in local coordinates;
- stakeout of points in local coordinates;
- stakeout of points in WGS84 coordinates.

Before proceeding with the calculation of the GPS resection verify that the coordinates of at least two local points are available. However it is suggested to use a minimum of four points.

The program can be provided with the local coordinates of the reference points in various ways:

- by adding the points manually to the *Point List* before (or during) the execution of the GPS resection
  (*Local pts from = ‹From this job›* option);
- by importing a DXF, CSV or other file, before starting the GPS resection
  (*Local pts from = ‹From this job›* option);

- by instructing the program to use the points saved in another job (*Local pts from = ‹From file...›* option).

Similarly, the program can be provided with the GPS coordinates corresponding to the local points in various ways:

- by taking a measurement which will determine the GPS coordinates for each local point selected for the calculation during the GPS resection phase (*GPS pts from = ‹Real Time›* option)
- by specifying to the program that the GPS coordinates have already been acquired/imported and have been saved in the active job (*GPS pts from = ‹From this job ›* option)
- by specifying to the program that the GPS coordinates have already been acquired/imported and have been saved in another job (*GPS pts from = ‹From file...›* option).

Unless the GPS coordinates of the points are defined through GPS measurement in real time, the following two mutually exclusive rules hold:

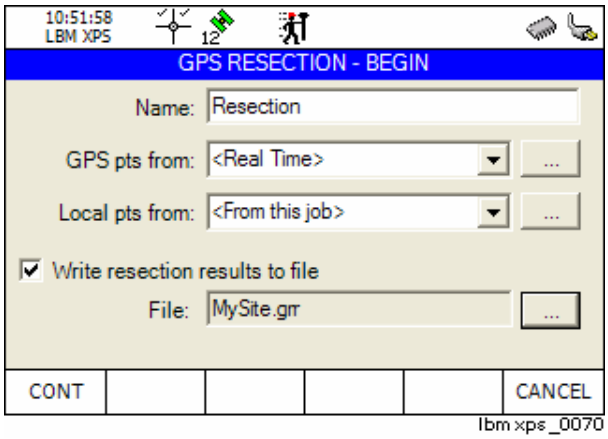
- **The local and GPS coordinates are saved in the active job:** there are points having double coordinates saved in the *Point List*:
  - local *e, n, h*
  - GPS *x,y,z* (or *lat, lon, hEll*).

- **The local and GPS coordinates are stored in separate jobs:** there are points in two different jobs that have *the same point code/number* and
  - in one job they have the local coordinates *e,n,h*;
  - in the other job they have the GPS coordinates *x,y,z* (or *lat,lon, hEll*).

In the calculation of the GPS resection, *a pairing type* can be specified for each pair of coordinates (for each point). The pairing type specifies to the program "if and why" to use a particular reference point. The following pairing types are possible:

- ***Pos. & Height***: the point must be used to calculate the planimetric and altimetric transformation parameters;
- ***Pos. only***: the point must be used to calculate the planimetric transformation parameters but must not influence the calculation of the altimetric transformation parameters;
- ***Height only***: the point must be used to calculate the altimetric transformation parameters but must not influence the calculation of the planimetric transformation parameters;
- ***Automatic***: the program verifies whether the local point has height; if affirmative, it chooses *Pos. & Height*; otherwise it chooses *Pos. only*;
- ***Pt. ignored***: the point must be ignored and not considered in the calculations.

To start the definition of the reference system through GPS resection, select the following items in sequence from the active job menu: *Reference System*, *GPS Resection*. The application will show the *GPS Resection - Begin* dialogue window for the definition of the following:



- ***Name***: name or description of the operation.
- ***GPS pts from***: origin of the GPS coordinates to be paired with the local coordinates of the reference points used in the calculation; the following possibilities are considered:
  - *‹From this job›*: the GPS coordinates corresponding to the local points have already been acquired and saved in the active job;
  - *‹Real Time›*: the GPS coordinates corresponding to the reference points are not available and will be acquired through GPS measurements;
  - *‹From file...›*: the GPS coordinates corresponding to the reference points have already been acquired and stored in another job which will be specified; selecting this option is equivalent to pressing the *[...]* button immediately to the right of the *GPS pts from* list.
- ***Local pts from***: the origin of the local coordinates to be paired with the GPS coordinates of the reference points used in the calculation; the following possibilities are considered:
  - *‹From this job›*: the local coordinates of the reference points are saved in the active job:
  - *‹From file...›*: the local coordinates of the reference points are stored in another job which will be specified; selecting this option is equivalent to pressing the *[...]* button immediately to the right of the *Local pts from* list.
- ***Write resection results to file:*** on activating this option, the program saves the coordinate transformation parameters in the GRR file specified by the user (press the *[...]* button to the right of the field *File* to specify the file name).

Press the *Cont* button to proceed to the next step of the reference system definition or press the *Cancel* button to exit.

If **it is not specified that the GPS coordinates be acquired in real time** (the *GPS pts from* option is not set on *‹Real Time›*):

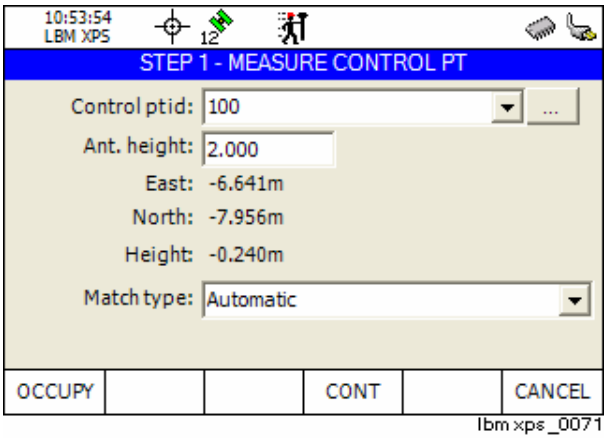
The program will run a search in the two jobs specified as *origin of the local coordinates* (*Local pts from* field) and *origin of the GPS coordinates* (*GPS pts from* field) in order to determine if there are points having:

1. the same point code/number
2. double coordinates in the local (e,n,q) and GPS (x,y,z or lat,lon,hEll) reference systems.

If the search is not successful then an error message is displayed and the user must modify the options (for example, the user has indicated a wrong job file or has not verified that the reference points have the same point name/number in the two jobs specified).

After having determined, by searching for the point code/number, the local and GPS coordinate pairs corresponding to the same point on the ground, the program will show the *Step 2- Match Points* dialogue window which lists these pairs. See further.

If **it is specified that the GPS coordinates be acquired in real time** (the *GPS pts from* option is set on *‹Real Time›*):



lbm xps_0071

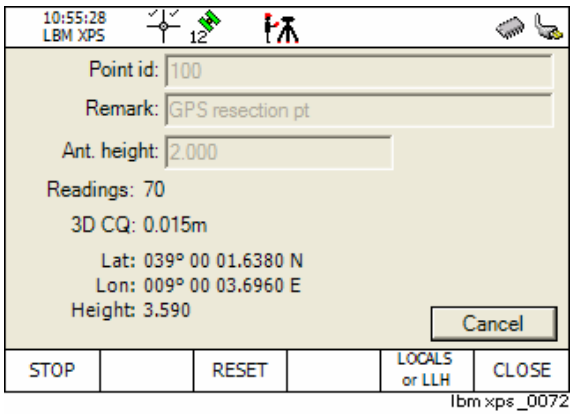
The program will show the *Step 1 – Measure Control Pt* dialogue window; this window is shown every time the measurement must be taken to determine the GPS coordinates to pair with the local coordinates of one of the reference points.

The user must specify:

- ***Control pt id:*** point code/number which identifies the local point to which the GPS coordinates must be associated; write the code or select an item from the drop down list or press the *[...]* button to select the point directly from the *Point List* (where it is also possible to create new points);
- ***Ant. height:*** height of the antenna (phase center);
- ***Match type:*** the type of pairing.

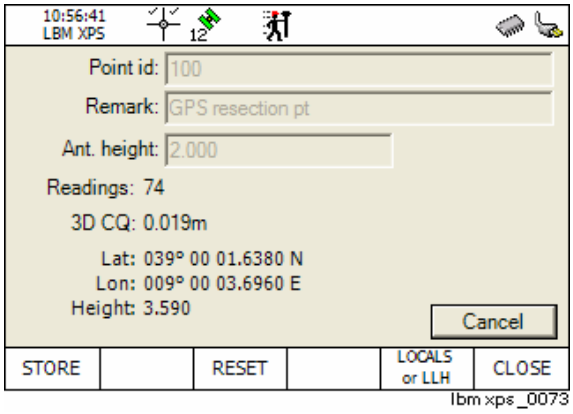
The user will then start the acquisition of the coordinates by pressing the *Occupy* button or will press *Cont* to not acquire the point and access the *Step 2 – Match Points* dialogue window which will list all the points for which the GPS coordinates have already been acquired through measurement.

If the user has pressed the *Occupy* button, the program will activate the acquisition phase and will show the following continuously on screen: the number of readings taken, the 3D CQ value and the current coordinates.
When the 3D CQ value (quality of the coordinates, gives the estimated error of the current GPS position in meters) rests at a value which is not very high (typically 1-2 centimeters or millimeters) press the *Stop* command (displayed in the place of the *Occupy* command during the acquisition phase).



lbm xps_0072

If the GPS could calculate the geographical coordinates (latitude and longitude), the *Store* command will show instead of the *Stop* command. Press the *Store* button to save the acquired point: the acquired GPS coordinates will be paired with the local coordinates of the same point, in fact, creating a point with double coordinates. The acquisition can be re-executed by pressing the *Reset* button and then pressing the *Occupy* button which will be displayed instead of the *Store* command. Alternatively, if the acquisition must be abandoned then press the *Close* button.



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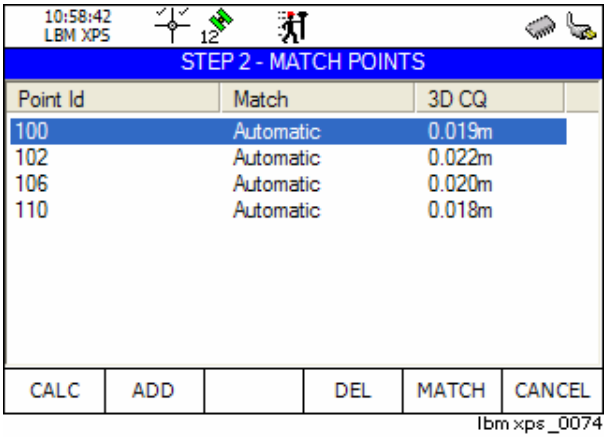
If the user proceeds to the saving of the coordinates, or presses the *Store* button, the program will show the *Step 2 – Match Points* dialogue window with a table that shows a list of the measured points: initially this table will contain a single point.

The user will add other reference points and will take their GPS measurements by pressing the *Add* button taking care to verify that the position of the point on the ground, chosen from the drop down list in the *Step 1 – Measure Control Pt* dialogue window, corresponds to the position occupied by the GPS in the measurement phase.

As soon as two or more points are present in the table shown in the *Step 2 – Match Points* dialogue window (either read automatically from file/job or added manually), the operator can try to calculate the GPS resection by pressing the *Calc* button.

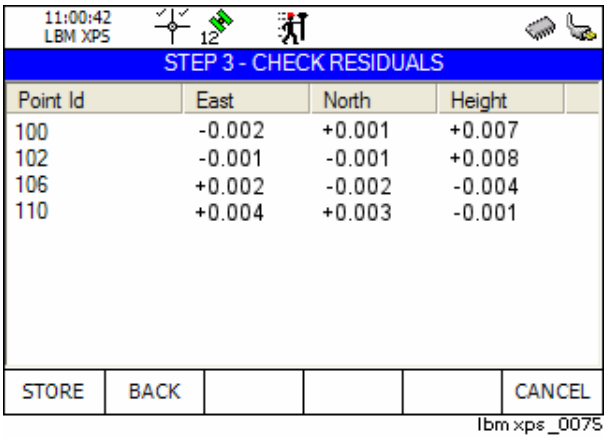


lbm xps_0074

Once the calculations have been made, the program will show the dialogue window *Step 3 – Check Residuals* which, for every point used in the calculation, shows the differences and residues among the local coordinates *e',n',h'* calculated through the transformation of the GPS coordinates and the original local coordinates *e,n,h* given as reference.

The operator will verify that the residue on the coordinates are within tolerance limits and if they are, will activate the new local reference system by pressing the *Store* button.

If differences are significant, he can:



lbm xps_0075

- Remove the points with high differences one by one and re-take GPS measurements (only if the *GPS pts from* option is set to *‹Real time›*);
- Exclude one or more points from the calculation (by using the pairing type, *Match* button) and forcing the recalculation of the resection (*Calc* button);
- Verify that the local coordinates of the points are correct;
- If possible use a different group of local points taking care to choose the points so that they are as far as possible from walls, trees or architectural elements which can reflect the GPS signals and give unreliable measurements (in this case, however, the 3D CQ value displayed in the acquisition phase would be high).

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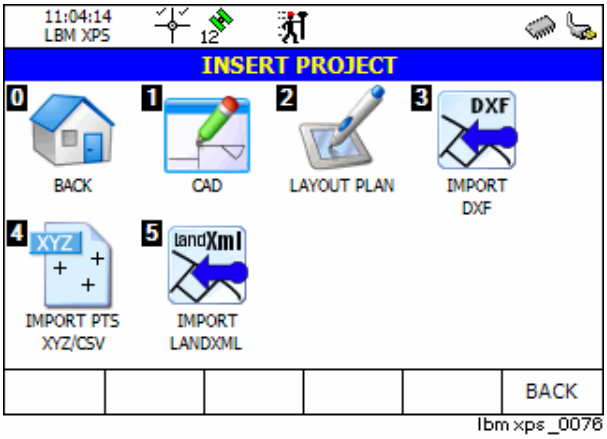
2.5. Project insertion



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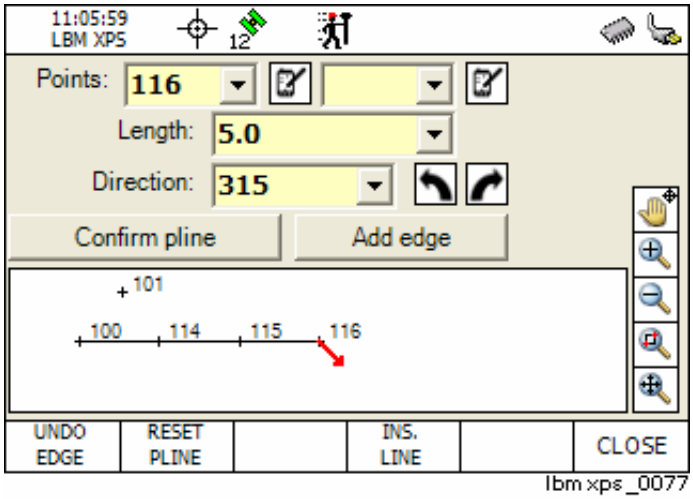

lbm xps_0077

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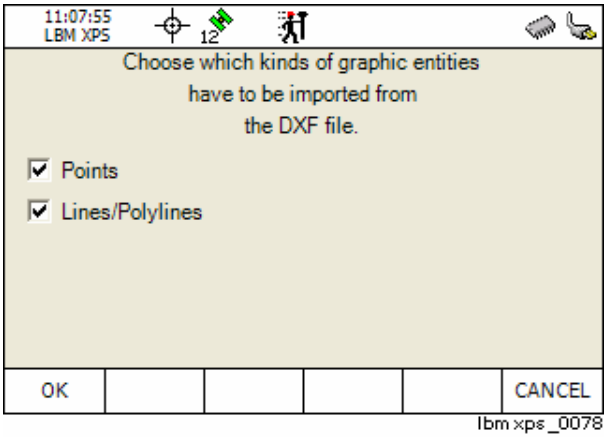


available memory after the import is not less than 50% of the total memory of palmtop (see Windows Start Menu, Settings, System, Memory or click on the electronic chip icon on the top right side of the screen). It is also to be noted that the graphics display speed of the procedure depends on the number of graphical entities imported.

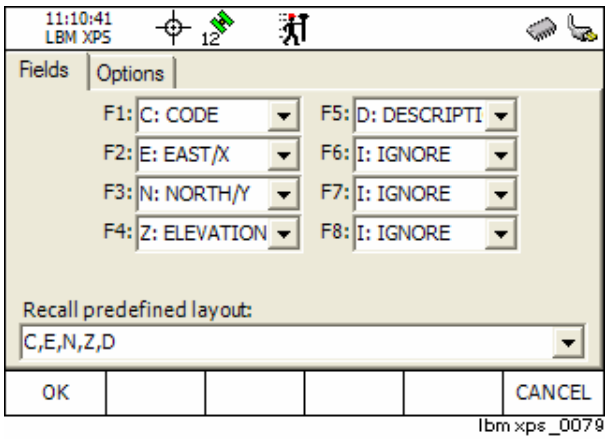
2.5.3. Importing points from a text file

The procedure allows lists of points to be imported from text files even if they have different formats.

To start the import, select the following items in sequence from the active job menu: *Insert Project*, *Import Pts XYZ/CSV*.

Select the text file to import and confirm.

A dialogue window will request that the format of the data in the file be specified. The parameters required for the definition of the format are given below.



lbm xps_0079

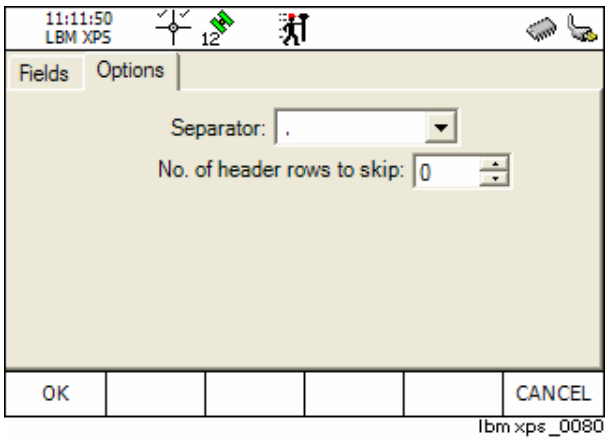
Fields: specify the content of the fields (up to 8 fields from C1 to C8). Each field can be associated with a type of content that the application supports: *ignore* (ignore the data), *point code/number*, *point description*, *north coordinate*, e*ast coordinate*, *height*.

The procedure suggests a predefined group of formats which can be activated from a drop down list situated on the lower part of the dialogue window. In this list the content of the field is abridged by displaying only the first letter as given in the table below:

- I = ignore/skip
- C = point code/description
- E = east coordinate
- N = north coordinate
- Q = height.

Separator: specifies the character used to separate the data (comma, semi colon, |, tab or space).

No. of header rows to skip: specify the number of lines to ignore at the beginning of the file. These lines, if present, usually contain the description of the fields in a human-readable format or other text that could prevent the data from being correctly imported.



lbm xps_0080

After the format has been defined, it can be verified if it is correct by pressing the *Try to import* button. The procedure will try to read the file without importing the data into the memory, thus it only reads the file to verify that the data is compatible with the C1-C8 definition. A message will show the result of the operation.

Any field after the eighth one will be completely ignored.

To start the data import, press the *OK* command or press *Cancel* to cancel.

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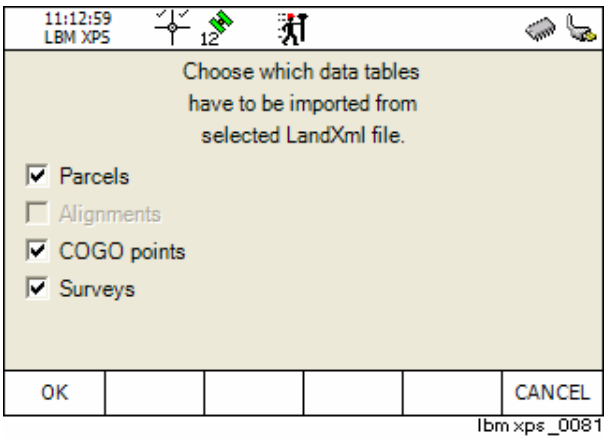
2.5.4. Import from LandXML

The procedure can import points and tacheometric data (stations and measurements) from a standard LandXML file.

To start the import, select the following items in sequence from the active job menu: *Insert Project*, *Import LandXML*.

Select the LandXML file to import and confirm.

A dialogue window will request to specify which data to import from:



lbm xps_0081

- Parcels (parcel perimeters)
- COGO points (points created by COGO operations);
- Surveys (stations and corresponding measurements).

All the imported points will be added to the *Point List*. The part related to surveys, if they exist, will be converted and inserted in the *Field book* (see *Data tables*).

After the import, the program will automatically display the CAD view.

2.6. Data tables

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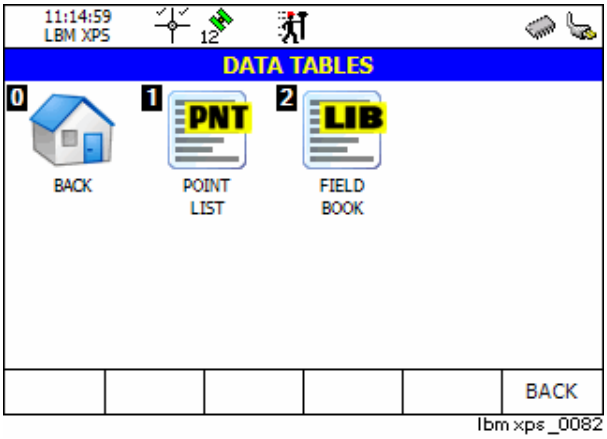
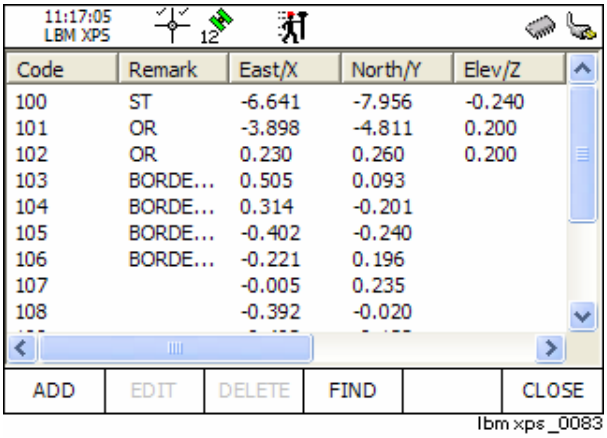
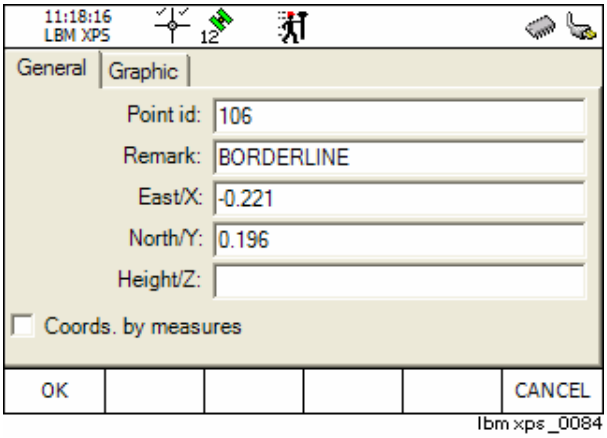


lbm xps_0082



lbm xps_0083



lbm xps_0084

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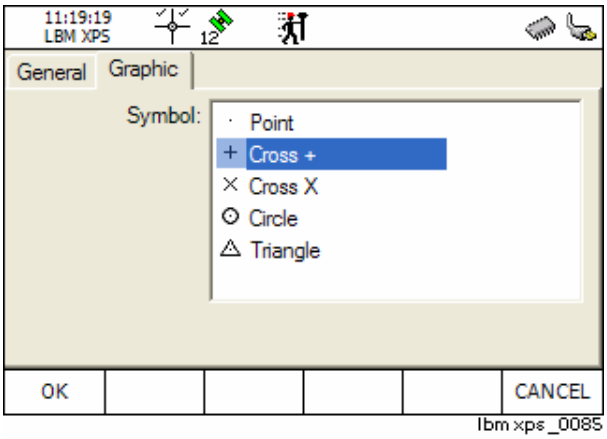


Modifying an existing point: to modify an existing point, select it in the list and then press the *Edit* button. The application will show a dialogue window to modify the data. This is the same dialogue window shown for the addition of a new point.

If the *Coords. by measures* option is checked then the point is a topographic point. The term "*by measures*" means that the coordinates of the point are assigned after (and at) each recalculation of the *Field book*. That is, the coordinates of a point can also vary following the variations brought to the *Field book* such as, for example:

- Change in a station coordinates
- Change in a station orientation angle
- Execution of a measurement both ways (foresight and backsight) which brings about the recalculation of the point coordinates using the average of the reduced distances.

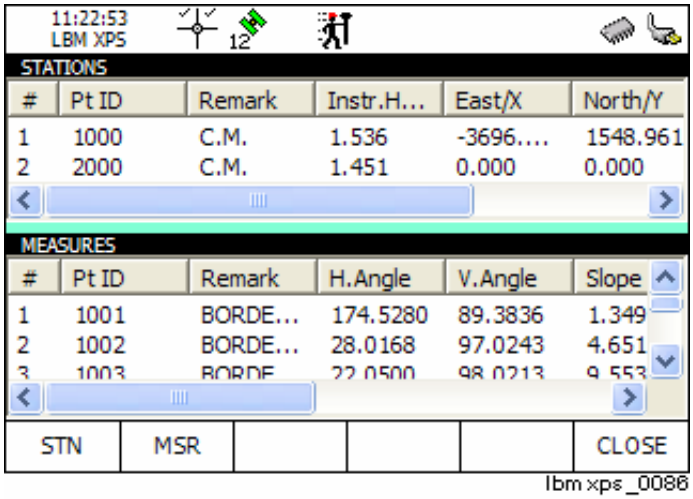
Deleting a point: to delete an existing point, select it in the list and then press the *Delete* button. The application will request a confirmation of the operation.

If the user tries to delete a point which is used as the orientation of a station, the program will give a warning message. Confirm only if you are sure that the deletion of the point will not lead to the loss of the station orientation. The deletion operation cannot be cancelled.

If the user tries to delete a point occupied by a tacheometric station, the program will display a warning message. Deleting the point also involves the deletion of all the tacheometric stations (from the *Field book*) which have occupied this point. Confirm only if you are sure that the deletion of the point and of the stations which occupy it (and the related measurements) is the actual operation to be executed. The deletion operation cannot be cancelled.

Searching for a point given its code/number: to select a point given its code/number, press the *Find* button, insert the code/number and confirm.

2.6.2. Field book


11:22:53
LBM XPS
STATIONS
Pt ID Remark Instr.H... East/X North/Y
1 1000 C.M. 1.536 -3696.... 1548.961
2 2000 C.M. 1.451 0.000 0.000
MEASURES
Pt ID Remark H.Angle V.Angle Slope
1 1001 BORDE... 174.5280 89.3836 1.349
2 1002 BORDE... 28.0168 97.0243 4.651
STN MSR CLOSE
lbm xps_0086

The *Field book* contains the list of stations used in the survey phase and the measurements carried out for each station. In fact, the application does not simply calculate the coordinates of the measured points to be later inserted into the *Point List*, but "remembers" the sequence of the stations and the measurements used to recalculate the coordinates. By modifying any one of the data in the *Field book* (for example modifying an instrument height in a station), the complete *Field book* will be recalculated and the coordinates of the points will be modified accordingly.

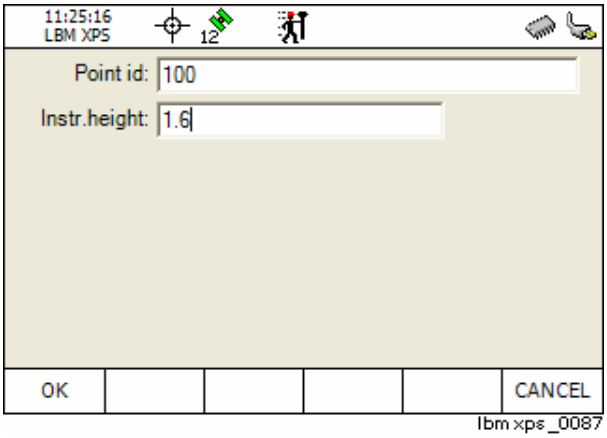
To access the *Field book*, select the following items in sequence from the active job menu: *Data Tables*, *Field Book*.

The application will show a dialogue window which contains two tables and a menu. The two tables are linked to each other: the first table (above) shows a list of all the stations carried out (in chronological order) while the second table (below) shows all the measurements taken by the station selected in the first table.

The following is shown for each station: station index, station point code/number, comment associated with the point, instrument height, point coordinates, point type (known/fixed or unknown/calculated).

The following is shown for each measurement: measurement index (corresponding to the station), code/number of the surveyed point, comment associated with the point, measurement data (horizontal angle, vertical angle, slope distance), prism height, coordinates of the point.

It is possible to: add, modify and delete a station, add, modify and delete a measurement.



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Add a station: select the *STN* command, a new series of commands will appear, press *NEW STN* then specify the code/number of a point and the instrument height. Confirm the data to create the station.

Note that the code/number of a non-existing point can be also specified: in this case, the application will show a dialogue window to insert the new point data.

Modify a station: select the station to be modified from the list and then select the *STN* command, a new series of commands will appear, press *EDIT STN*. Modify the point code/number associated with the station and/or the instrument height then confirm the data.

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If the point code/number is modified, one of the following situations will happen:

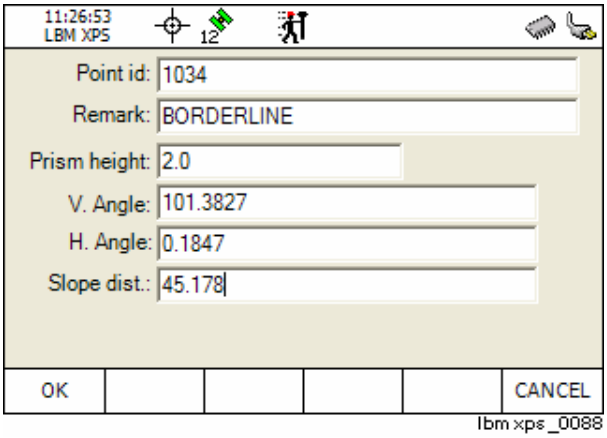
- The code/number specified does not correspond to any point in the *Point List*. The application will ask whether to create a new point or simply rename the point by assigning a new code/number to it.
- The code/number specified corresponds to a point already in the *Point List*. After confirmation, the application will reassign the station from the previous point to the point with the specified code/number.

The modification of a station data will lead to the recalculation of the *Field book*.

Delete a station: select the station to be deleted from the list and then select the *STN* command, a new series of commands will appear, press *DEL STN*. The application will request a confirmation of the operation and will delete the station and all the measurements taken by that station.

The deletion of a station will lead to the recalculation of the *Field book*. The points surveyed by the station will not be deleted, however, their coordinates may change on account of the measurements taken towards them by another station (in case of hyper-determined points, the coordinates assigned are the average of the coordinates obtained by each measurement towards these points).

Add a measurement: Select the station from the list and then select the *MSR* command, a new series of commands will appear, press *NEW MSR*. Specify the code/number of the point to be measured, a comment (optional), prism height (optional), measurement data (horizontal angle, vertical angle, inclined distance). Confirm the data.



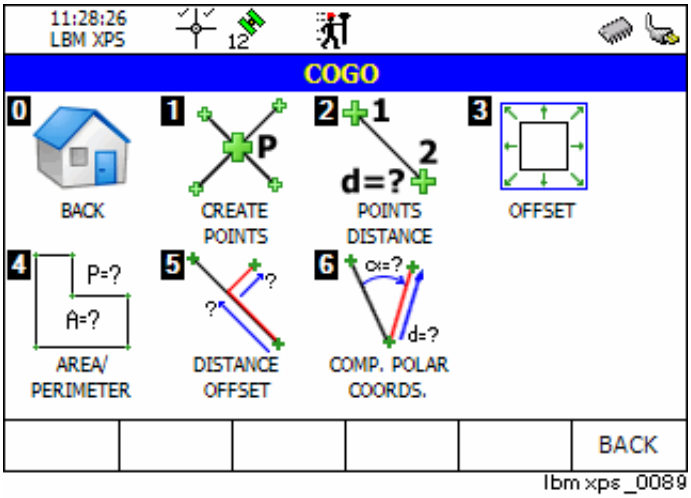
lbm xps_0088

The addition of a measurement will recalculate the *Field book*. If the point indicated by the measurement has **known and fixed** coordinates (*Coords. from measures* option is not checked in the property page of the point) then its coordinates will not vary but the orientation of the station can vary due to the automatic use of the known point as orientation. If, on the other hand, the point has **tacheometry calculated coordinates** since it is referenced from at least another measurement of those present in the *Field book*, then its coordinates can vary due to the hyper-determination which will lead to the calculation of the average of the coordinates obtained by each measurement towards this point.

Delete a measurement: select a station from the list then select the measurement to be deleted. Select the *MSR* command, a new series of commands will appear, press *DEL MSR*. The application will request a confirmation of the operation and then will delete the measurement.

The deletion of a measurement will lead to the recalculation of the *Field book*. The point referenced by the measurement will not be deleted; however, its coordinates may change on account of the measurements taken towards the same point by other stations (or in case of hyper-determined points, the coordinates assigned are the average of the coordinates obtained by each measurement towards these points).

2.7. COGO Calculations



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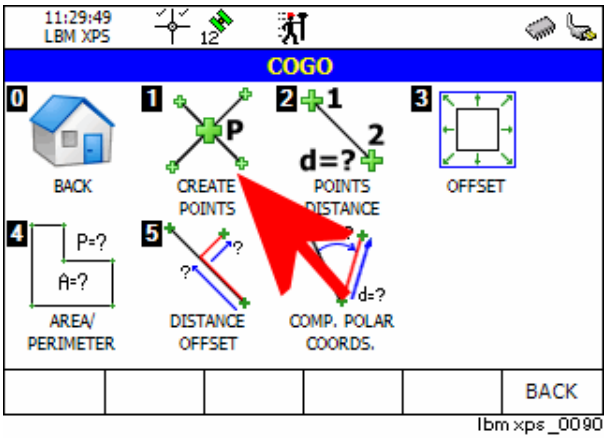

lbm xps_0090

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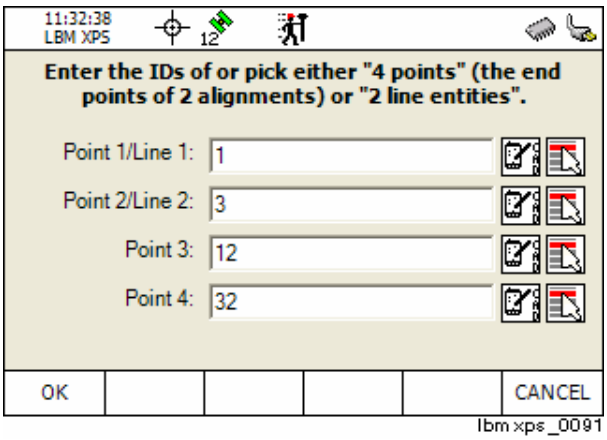
2.7.2. Creation of points from the intersection of alignments/lines



A point can be created on the intersection of two alignments or two lines. In the first case, four points must be specified; two for each alignment. In the second case, two lines must be specified (already designed in CAD).

To start the command to calculate the intersection, select the following items in sequence from the active job menu: *COGO*, *Create Points*, *By Intersection*. The application will show a dialogue window to input the data.

Intersection of alignments: specify the codes/numbers of two points for alignment #1 in the *Point 1* and *Point 2* fields; specify the codes/numbers of two points for alignment #2 in the *Point 3* and *Point 4* fields.

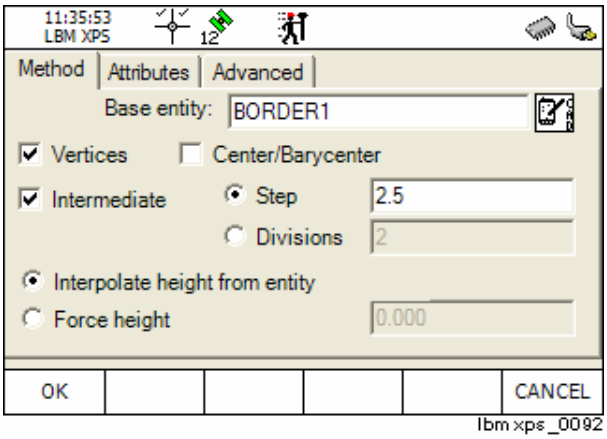
Intersection of lines: specify the codes/numbers of the two graphical entities (lines) in the *Line 1* and *Line 2* fields. Leave the *Point 3* and *Point 4* fields empty.

To specify the points and the lines, a selection can be made from CAD by pressing the first button to the right of each field. For points only, a point can also be selected from the *Point List* by pressing the second button to the right of each field.

Press the *OK* command to start the calculation of the new point. The application will show a dialogue window to input the data. The point code/number is suggested automatically and the coordinates are those obtained from the calculation of the intersection.

Confirm the data to create the point.

2.7.3. Creation of points from graphical entities



New points can be created using an existing CAD entity as reference. By properly operating on certain simple parameters, it will be possible to create *new points on the vertices* of the entity, a *point in the centre* of the entity or a group of points placed at *constant distances* along the entity or so many as to *divide the entity in equal parts*.

To start the command to calculate the new points from a graphical entity, select the following items in sequence from the active job menu: *COGO*, *Create Points*, *From Graph. Entity*. The application will show a dialogue window to input the data.

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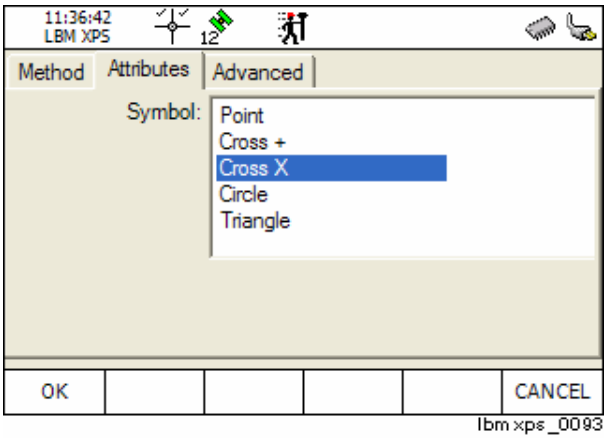
Specify the reference graphical entity by writing its code/number in the *Base entity* field or select the entity from the CAD by pressing the button placed immediately to the right of the field.

Specify if new points must be created along the vertices and/or the centre/barycentre of the graphical entity.

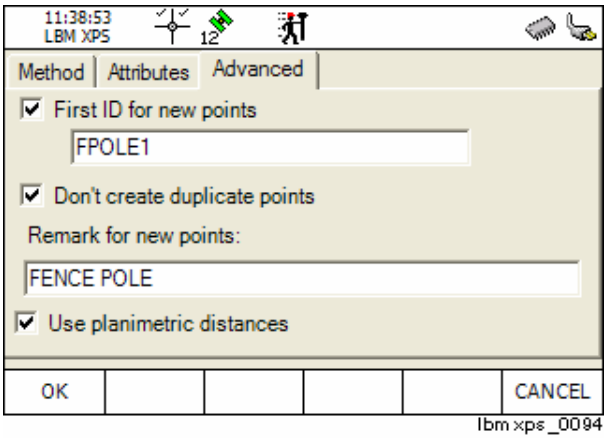


lbm xps_0093

Also specify, by marking the *Intermediate* option, if *intermediary* new points must be created along the perimeter of the graphical entity. The new intermediary points can be placed so that their distance is equal to a set value (*Step* option) or so as to divide the perimeter into equal parts (*Divisions* option).

The heights of the new points can be obtained (by interpolation if required) directly from the height of the graphical entity (*Interpolate height* option) or set to a particular value (*Force Height* option).

It is possible to specify which graphical symbol to associate with the new points: access the *Attributes* page and select a symbol from the list.



lbm xps_0094

The new points will be automatically numbered by the application with progressive codes/numbers. To set a particular numbering, access the *Advanced* page then activate the *First ID for new points* option, enter the code/number to assign to the first point.

To avoid overlapped/duplicated points (with the same coordinates), open the *Advanced* page and activate the *Don't create duplicate points* option.

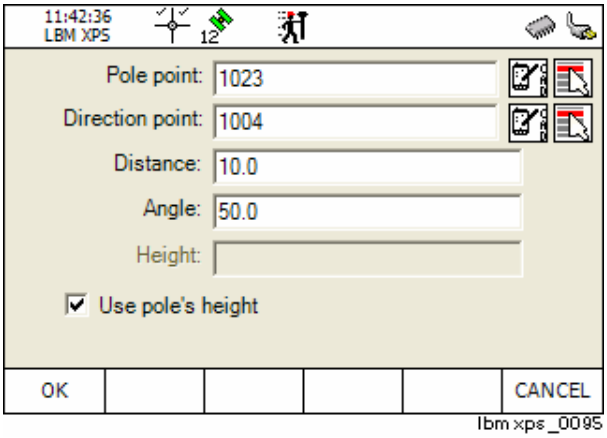
To assign a description to the new points, open the *Advanced* page and enter the description in the field specified as *Remark for new points.*

Note that **the distance** specified **to create the intermediary points** at fixed distances or by division into equal parts, **is interpreted by the application as a planimetric/horizontal distance**. To also include the height in the calculation of distances, that is to use an slope distance, enter the *Advanced* page and deactivate the *Use planimetric distances* option.

Press the *OK* command to start the calculation or the Cancel command to exit without creating points.

At the end of the calculations, the application will show a message with the number of new points created and, if it is the case, the number of points that have not been created because they already exist in the CAD (points which would be overlapped by other points having identical coordinates).

2.7.4. Creation of points by polar coordinates



New points can be created by specifying a distance with respect to a pole and an angle with respect to an alignment that is by specifying a polar measure.

To start the command to calculate the new points by polar coordinates, select the following items in sequence from the active job menu: *COGO*, *Create Points*, *By Polar Coords*. The application will show a dialogue window to input the data.

Specify the code/number of the point to be used as the pole in the *Pole point* field, then specify the code/number of the point to be used to define the reference alignment for the angle in the *Direction point* field. The alignment is always considered as passing through the pole.

To specify the base points, a selection can be made from CAD by pressing the first button to the right of each field. A point can also be selected from the *Point List* by pressing the second button to the right of each field.

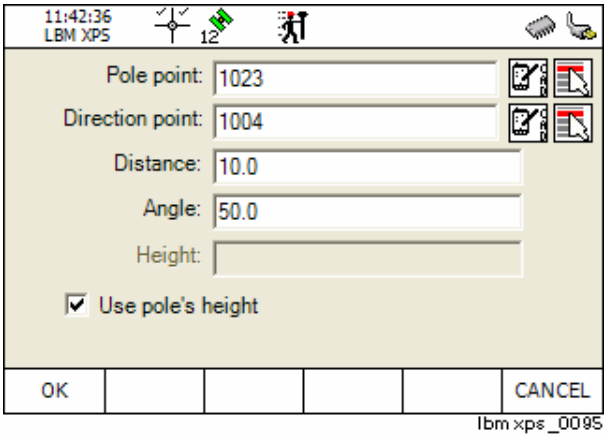
Specify the (planimetric) distance from the pole and the angle with respect to the orientation (horizontal angle, clockwise).

The height of the new point is automatically set to the pole height. To set the height to a particular value, deactivate the *Use pole's height* option and then enter the new height in the *Height* field.

Press *OK* to start the calculation. The application will show a dialogue window to input the data of the new point: the code is suggested automatically and the coordinates are those obtained from the calculation.

Confirm the data to create the point.

2.7.5. Creation of points from distance and perpendicular offset



New points can be created by specifying a distance along an alignment (with ref. to a pole) and an perpendicular offset from the alignment.

To start the command to calculate the new points from distance and perpendicular offset, select the following items in sequence from the active job menu: *COGO, Create Points, By Dist. And Ofs.* The application will show a dialogue window to input the data.

Specify the code/number of the point to be used as the pole in the *Pole point* field, then specify the code/number of the point to be used to define the reference alignment in the *Direction point* field. The alignment is always considered as passing through the pole.

To specify the base points, a selection can be made from CAD by pressing the first button to the right of each field. A point can also be selected from the *Point List* by pressing the second button to the right of each field.

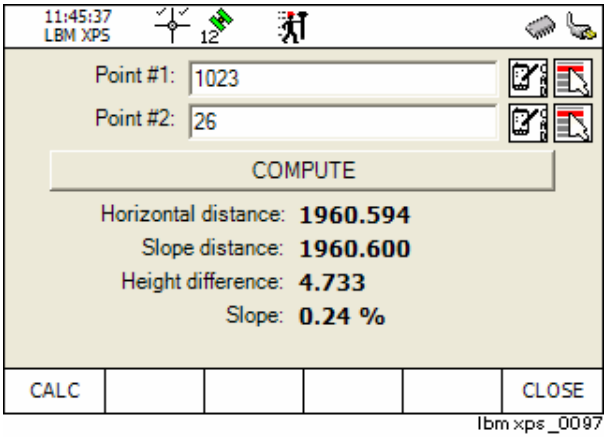
Specify the (planimetric) distance from the pole and the (planimetric) distance with respect to the alignment (positive towards the left of the alignment, negative towards the right).

The height of the new point is automatically set to the pole height. To set the height to a particular value, deactivate the *Use pole's height* option and then enter the new height in the *Height* field.

Press *OK* to start the calculation. The application will show a dialogue window to input the data of the new point: the code is suggested automatically and the coordinates are those obtained from the calculation.

Confirm the data to create the point.

2.7.6. Calculation of the distance between two points



To start the command to calculate the distance between two points, select the following items from the active job menu: *COGO*, *Points Distance*. The application will show a dialogue window to input the data.

Specify the code/number of the first point in the *Point 1* field then specify the code/number of the second point in the *Point 2* field.

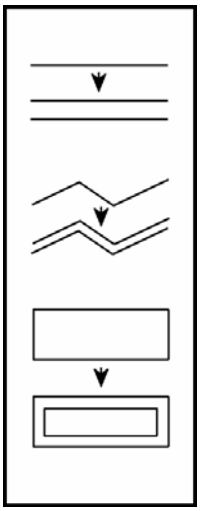
To specify the points, a selection can be made from CAD by pressing the first button to the right of each field. A point can also be selected from the *Point List* by pressing the second button to the right of each field.

Press the *Calc* button to perform the calculation.

The application will show the horizontal distance and, if it can be calculated, the slope distance between the two points and the slope in percentage (level difference and slope are calculated by taking point #1 as the pole).

Press the *Close* command to return to the COGO menu.

2.7.7. Calculation of the parallel figure (offset)



A figure can be created parallel to a given figure already present in the CAD, for example:

- a segment parallel to a given segment;
- a poly-line (side by side) to a given poly-line;
- enlargement/reduction of a given perimeter, that is of a closed polygon.

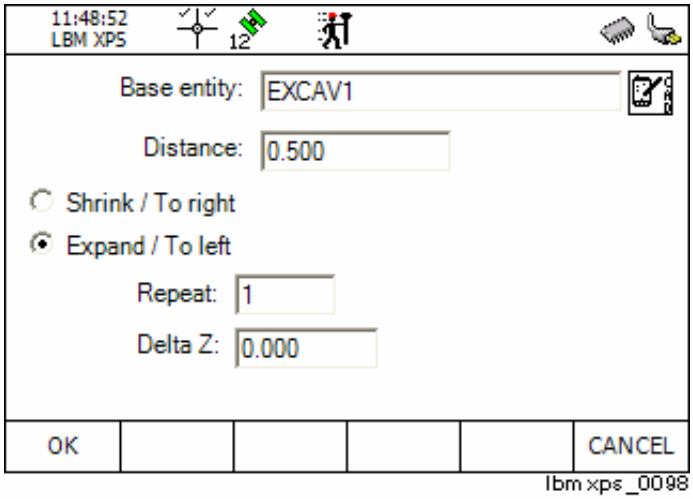
To start the command to calculate the parallel figures, select the following items in sequence from the active job menu: *COGO*, *Offset*. The application will show a dialogue window to input the data necessary for the calculation.

Specify the code/number of the figure to offset in the *Base entity* field, or alternately, press the button to the right of the field to directly select the figure from CAD.

Specify the orthogonal distance to be maintained between the sides of the given figure and the parallel figure in the *Distance* field.

Specify where to place the parallel figure with regards to the given figure:

- if the figure is a line or poly-line (open) either the *To right* or the *To left* option;
- if the figure is a polygon (closed poly-line) specify if a reduction (*Shrink*) or enlargement (*Expand*) must be performed.



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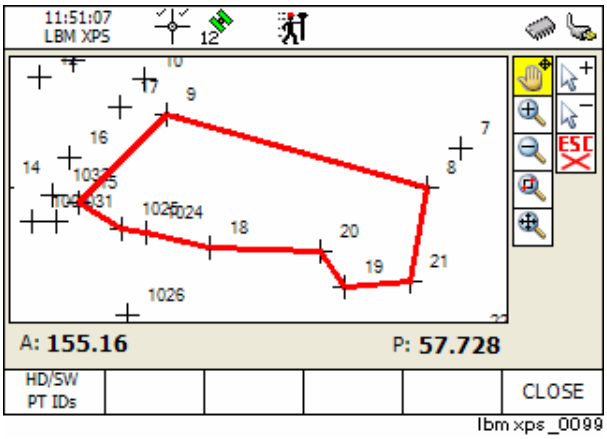
Then, in the *Repeat* field, specify the number of times the parallel figure calculation must be executed: if a value greater than one is specified, the figure undergoing the parallel calculation will be the result of the previous calculation. In short, a figure parallel to a given figure can be calculated, then the figure parallel to the calculated parallel figure and so on.

Indicate the level difference to be applied to the resulting parallel figure in the *Delta Z* field. The level difference will be applied to each vertex of the parallel figure – the vertices will initially have the same height as the vertices of the given figure.

Press the *OK* command to proceed with the calculation or press the *Cancel* button to end the operation.

After calculating the parallel figure, the program will automatically open the CAD from where the result of the operation can be verified or delete the entity just created in case the result is not the expected one on account of wrong calculation parameters.

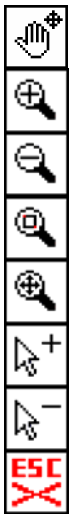
2.7.8. Calculation of the area and perimeter of a closed figure



The area and perimeter of a closed figure can be calculated by specifying the vertices of the perimeter.

To start the command to calculate the area and perimeter, select the following items in sequence from the active job menu: *COGO*, *Area/Perimeter*. The application will show a dialogue window to input the data.

The dialogue window will show the map in a small CAD. The CAD has several tools (buttons to the right) to perform pan/zoom, selecting and deselecting the figure vertices. The table below gives a brief description of each tool:



Pan: Tap and drag to move the map

Zoom in: Tap to enlarge

Zoom out: Tap to reduce

Zoom window: Tap and drag to define the rectangular area to enlarge

Zoom to fit: Show the entire map

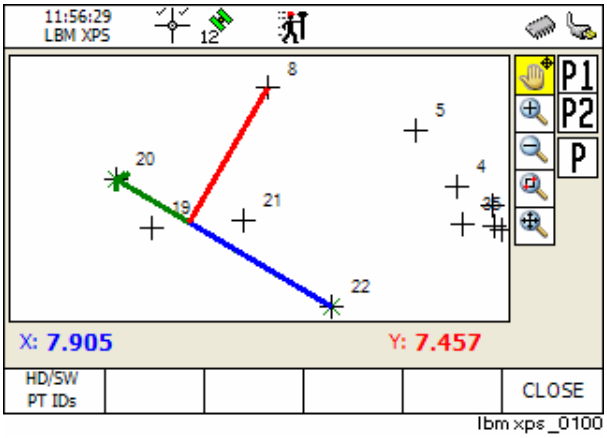
Select a vertex: Tap on a point to select it

Unselect a vertex: Tap on a point to deselect it

Esc: Restarts the selection of the figure vertices

The specifications of the area and the perimeter of the figure are shown immediately below the CAD view. These values are automatically updated upon every selection/de-selection of a vertex on the figure perimeter.

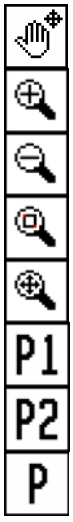
2.7.9. Calculation of the distance and perpendicular offset



The distance and perpendicular offset of a point with respect to an alignment can be calculated.

To start the command to calculate the distance and perpendicular offset, select the following items in sequence from the active job menu: *COGO*, *Distance Offset*. The application will show a dialogue window to input the data.

The dialogue window will show the map in a small CAD. The CAD has several tools (buttons to the right) to perform pan/zoom, defining the alignment and indicating the point for which the perpendicular must be calculated. The table below gives a brief description of each tool:



Pan: Tap and drag to move the map

Zoom in: Tap to enlarge

Zoom out: Tap to reduce

Zoom window: Tap and drag to define the rectangular area to enlarge

Zoom to fit: Show the entire map

Define the pole of the alignment: Tap on a point to select it

Define the orientation of the alignment: Tap on a point to select it

Point for which the distances have to be computed: Tap on a point to select it

To define the reference alignment (pole P1 › orientation P2), use the P1 and P2 buttons. Then press P to specify the point for which to calculate the distance and the perpendicular offset with respect to the given alignment.

The distance is calculated along the alignment starting from point P1. The perpendicular offset is calculated orthogonal to the alignment.
The specifications of the distance (value *X*) and the offset (value *Y*) are shown immediately below the CAD view. These values are automatically updated upon every variation of the point to be calculated or the alignment.

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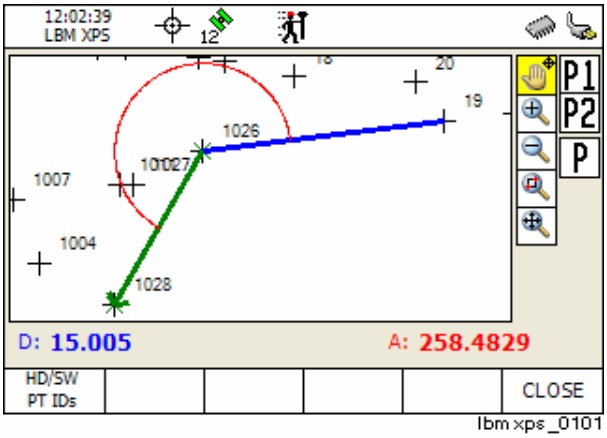
The CAD view also shows:

- a green arrow, from P1 to P2, to represent the direction of the alignment;
- a blue segment, which may hide a part of the green arrow, which represents the distance calculated along the alignment starting from P1;
- a red segment, orthogonal to the green arrow and the blue segment, which represents the perpendicular offset.

The alignment is taken to extend to infinity: hence it is possible to calculate the distance and perpendicular offset of the points whose orthogonal projection does not fall in the segment that joins P1 and P2.

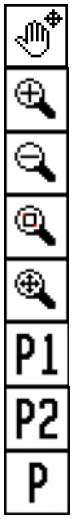
2.7.10. Calculation of the polar coordinates



The polar coordinates of a point with respect to an alignment passing through two given points (pole and orientation) can be calculated.

To start the command to calculate the polar coordinates, select the following items in sequence from the active job menu: *COGO*, *Comp. Polar Coords*. The application will show a dialogue window to input the data.

The dialogue window will show the map in a small CAD. The CAD has several tools (buttons to the right) to perform pan/zoom, defining the alignment and indicating the point for which the polar coordinates must be calculated. The table below gives a brief description of each tool:



Pan: Tap and drag to move the map

Zoom in: Tap to enlarge

Zoom out: Tap to reduce

Zoom window: Tap and drag to define the rectangular area to enlarge

Zoom to fit: Show the entire map

Define the pole of the alignment: Tap on a point to select it

Define the orientation of the alignment: Tap on a point to select it

Point for which the polar coordinates have to be computed: Tap on a point to select it.

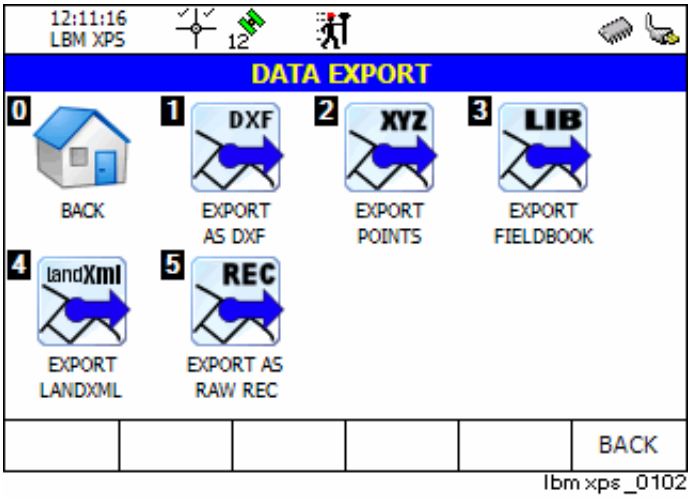
To define the reference alignment (alignment passing through a pole and an orientation), use the *P1* and *P2* buttons. Then press *P* to specify the point for which to calculate the polar coordinates.

The specifications of the (planimetric) distance from the pole and the horizontal angle (clockwise) with respect to the alignment are shown immediately below the CAD view. These values are automatically updated upon every variation of the point to be calculated or the alignment.

The CAD view also shows:

- a green arrow, from P1 to P2, to represent the direction of the alignment;
- a blue segment, which may hide a part of the green arrow, unites the pole P1 of the alignment to point P and represents the calculated distance;
- a red arc to represent the calculated angle.

2.8. Data exporting



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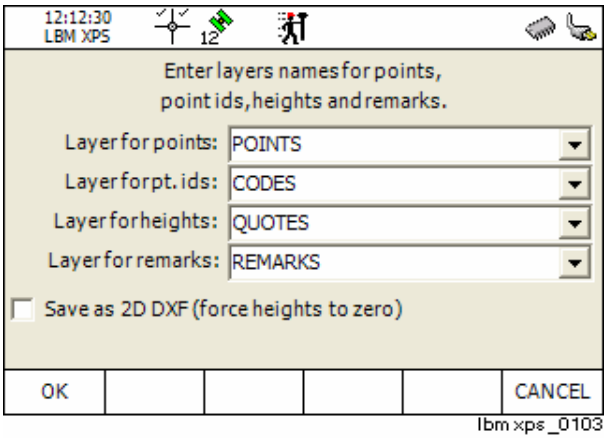

lbm xps_0103

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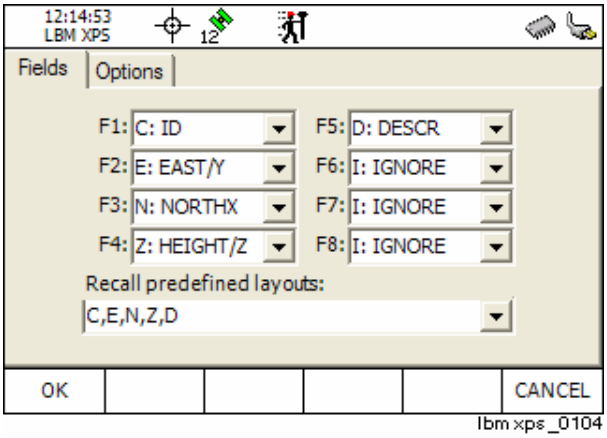

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Field description: specify the meaning of the fields (up to 8 fields, from C1 to C8). A meaning, among those supported by the application, can be associated with each field i.e.: empty (null field), point code/number, point description, north coordinate, east coordinate and height.

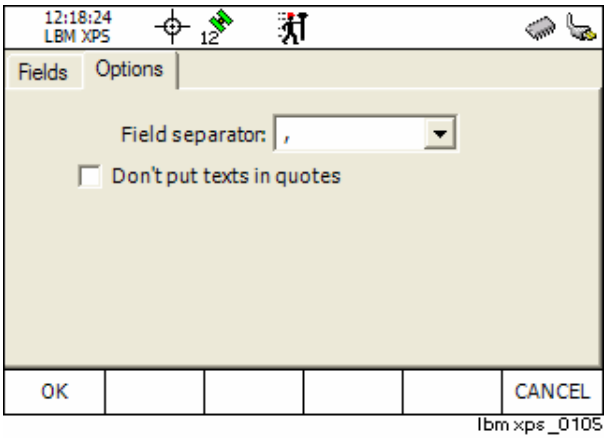
Each line of exported data will be composed of fields in order from C1 to C8.

The procedure suggests a group of predefined formats which can be activated from a drop down list placed in the lower part of the dialogue window. In this list the meaning of the fields is shown in an abridged form, by specifying only the initial letter as per the following table:

- I = empty/null
- C = point code/number
- D = point description
- E = east coordinate
- N = north coordinate
- Z = height.

In the second page of the dialogue window, the following can be specified:

- *Separator* option: select the character to be used to separate the data fields (comma, semi-colon, |, tab or space);
- *Don't put texts in quotes* option: the text (point code/number, comments) is automatically enclosed in double quotes; check the option to not enclose the text within double quotes.



lbm xps_0105

Press the *OK* command to start the data export or press the *Cancel* button to cancel.

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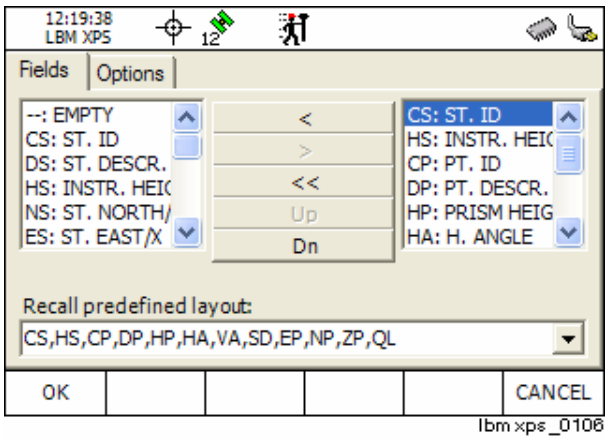
2.8.3. Export the Field book to CSV

The *Field book* can be exported into a text file in CSV format.

To start the export, select the following items in sequence from the active job menu: *Data Export*, *Export Fieldbook*.

Specify the name of the destination file and confirm.



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The program will show a dialogue window to specify the export parameters, that is to fix the order of fields for writing the data into the file. The parameters required to define the format are given below.

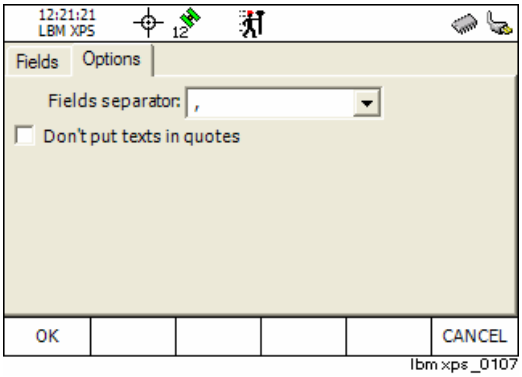
Field description: specify the order and the meaning of the fields by selecting an item from the list to the left and then press the "›" key to add it to the list to the right.

The procedure suggests a group of predefined formats/layouts which can be activated from a drop down list placed in the lower part of the dialogue window. In this list the meaning of the fields is shown in an abridged form, by specifying two capital letters as per the following table:

- -- = empty/null
- CS = station point code/number
- DS = station description
- HS = instrument height
- NS = north coordinate of the station point
- ES = east coordinate of the station point
- ZS = station point height
- CP = code/number of the measured point
- DP = description of the measured point
- NP = north coordinate of the measured point
- EP = east coordinate of the measured point
- ZP = measured point height
- HA = horizontal angle (azimuth)
- VA = vertical angle (zenith)
- SD = slope distance
- HD = horizontal distance
- ED = height difference
- HP = prism height
- QL = plotted point quality (known/fixed or unknown/calculated from tacheometry).

In the second page of the dialogue window, the following can be specified:

- *Separator* option: specify the character to be used to separate the data (comma, semi-colon, |, tab or space);
- *Don't put texts in quotes* option: the text (point codes/numbers, comments) is automatically enclosed in double quotes; check the option to not enclose the text within double quotes.



lbm xps_0107

Press the *OK* command to start the data export or press the *Cancel* button to cancel.

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2.8.4. Export the Field book to LandXML

The *Field book* can be exported into a text file in LandXML format.

To start the export, select the following items in sequence from the active job menu: *Data Export*, *Export LandXML.*

Specify the name of the destination file and confirm.

There are no export options and the data is organized as per the LandXML version 1.1 standard.

In brief:

- All the points in the *Point List* are exported in a *CgPoints* type group having *CgPoint* type elements, each corresponding to a point with the point code/number, comment, east and north coordinates and height (if it is known);
- All the tacheometric stations in the *Field book* are exported as *InstrumentSetup* type elements and the corresponding measurements are exported in *ObservationGroup* type groups containing *RawObservation* type elements with data in the HA,VA and SD format.

To read the file generated in this manner, an application must be used to import the LandXML (the text is encoded in UTF-8 standard). The generated file, even if it is plain text, has a complex structure and the user must not operate on it using a text editor.

2.8.5. Export the Field book to GSI

The *Field book* can be exported into a text file in GSI 16 format.

To start the export, select the following items in sequence from the active job menu: *Data Export*, *Export As Raw REC*.

Specify the name of the destination file and confirm.

A line is created for each tacheometric station with:

- WI 11: point code/number
- WI 84: east coordinate
- WI 85: north coordinate
- WI 86: height
- WI 88: instrument height (WI is not written if the instrument height is not specified)

A line is created for each tacheometric measurement with:

- WI 11: point code/number
- WI 21: horizontal angle
- WI 22: vertical angle
- WI 31: inclined distance
- WI 87: reflector height
- WI 71: comment.